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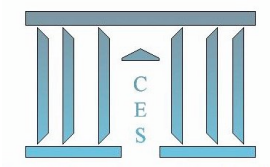

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Dating Business Cycle Turning Points for the French Economy: a MS-DFM approach*

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Abstract

The official institutions (NBER, OECD, CEPR and others) provide business cycle chronology with a lag from 3 months up to several years. Markov-Switching Dynamic Factor Model (MS-DFM) allows to produce the turning points more timely. The Kalman filter estimates of the model can be obtained in one step with limited number of series or in two steps on a much richer dataset. While the choice of correct series is a challenge for the one-step method, the problem of the two-step method is the potential misspecification. In this paper we apply one-step and two-step approaches to the French data and compare their performance. Both methods give qualitatively similar results and prove to reproduce the OECD business cycle chronology on the 1993-2014 monthly sample well. We find that the two-step method is more precise in determining the beginnings and the ends of recessions. Also, both methods produce extra signals corresponding to downturns which were too short to belong to OECD chronology of recessions.

JEL Classification: C32, C34, C55, E32

Keywords: Dynamic factor models, Markov switching models, business cycle turning points

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1 Introduction

The knowledge of the current state of the economic cycle is essential for policymakers. However, it is not easy to determine. In fact, a certain time is to pass before the official institutions announce the state of today. NBER and CEPR produce the reference economic cycle dating for the USA and Europe, respectively, on a basis of a consensus of expert opinions with a lag of several months or years. The OECD reference economic cycle dating for Europe is based on the quarterly GDP series, so the monthly chronology is updated every quarter only, *i.e.* with a lag of up to 3 months. Other institutions, such as ECRI[3], provide dating with at least one year lag. Besides the timing, another complicated issue is the definition of recession and setting the list of series that should be taken into account as indicators of the economic cycle. It is not clear whether we should consider the recession over if the industrial production is reanimated but the unemployment rate is still high and keeps rising. A straightforward example of such case are the consequences of the 2008 crisis, when the improvements in the world economic rebound growth were not sufficient to employ 197 million and 202 million of extra labor in 2012 and 2013, respectively. Finally, which method should be used to determine turning points? Several procedures can be used, and the results are likely to differ. Therefore, due to the timing of new releases of economic data, ambiguity of definition and methodological issues, the identification of the current state of the economy is a complicated task. We attempt to tackle these three problems in case of the French economic cycles on the basis of the Markov Switching Dynamic Factor Model.

The Dynamic Factor Model with Markov Switching (MS-DFM) was first suggested by Diebold and Rudenbusch (1996)[4]. This paper relies on the seminal paper by Hamilton (1989) which applies a univariate Markov-Switching model to business cycle analysis. It was then formalized for the multivariate case by Kim, Yoo (1995) and used extensively afterwards by Chauvet (1998), Kim, Nelson, (1998), Kauffmann (1998). The model allows to consider two features of an economic cycle, as described by Burns and Mitchell (1946), namely the comovement of individual economic series and the division of an economic cycle into two distinct regimes, recession and expansion. Thus, the common factor of the economic series contains the information on the dynamics of the economic activity, while the two-regime pattern is captured by allowing the parameters of the factor dynamics to follow a Markov-chain process. While the original model assumed switches in mean, other types of non-linearity were proposed by Kholodilin (2002a, 2002b), Dolega (2007), Bessec, Bouhabdallah (2007) where the slope of factors or exogenous variables is state dependent; or by Chauvet (1998, 1999), Kholodilin (2002a, 2002b), Kholodilin, Yao (2004), Anas et al., (2007) where the variance of idiosyncratic component is state dependent; and lastly by Chauvet, Potter (1998) and Carvalho, Lopesa (2006) where the authors allow for structural breaks in factor loadings.

The MS-DFM model can be estimated either in one or two steps. The one-step method implies estimation of parameters of the model and factor series simultaneously, under specific assumptions on the dynamics of the factor. The two-step method consists of 1) extraction of a composite indicator reflecting the economic activity (the factor); 2) estimation of the parameters of the univariate Markov-Switching model on factor series. As usual, each method has its advantages and disadvantages. The one-step approach is given more favor in the literature since, within this method, the extracted factor is designed so that it has Markov-switching dynamics. On the other hand,

[3]Economic Cycle Research Institute, a private organisation.
[4]The working paper version appeared in 1994 in NBER Working Papers 4643.

the one-step approach is subject to convergence problems and is more time-consuming, since the number of parameters to estimate is much larger than in the case of two-step procedure, and increases with the number of series in the database. Thus, it is necessary to choose a set of variables that would reflect the oscillations of the economic activity correctly. The two-step procedure is much easier to implement, is flexible in model specification and does not put any limits on the number of series by default. This is why it has been used in a number of papers, for example by Chauvet, Seynuz (2008), Darné, Ferrara (2011), Bessec, Boubdallah (2014) and others. However, Camacho, Perez-Quiroz, Poncela (2012) showed that this method may face misspecification issues, as the factor extracted on the first step does not necessarily follow a non-linear dynamics. More precisely, the authors argued that when estimated with a linear DFM, the factor may give too much weight to the past values of underlying series, thus being slow to reflect the most recent changes. Therefore, the choice of the estimation method implies a trade-off between the advantages of large datasets and these potential misspecification problems.

In this paper we analyze and compare the results of these two estimation methods for a dataset of French economic series. We estimate the MS-DFM for the period May 1993 - March 2014 via the two-step method on a large database containing 151 series and via the one-step method on 4 series, as suggested by the original paper of Kim, Yoo (1995). In order to select variables for the one-step method we test all possible combinations by 4 from 25 main economic indicators of the French economy, *i.e.* 12650 combinations. It is necessary to precise that here we understand the economic cycle in the sense of the growth rate cycle, *i.e.* the fluctuations of the growth rates of economic activity.

Comparing the results of the one-step method on different datasets, we determine the key economic indicators that are able to give early and accurate signals on the current state of the growth rate cycle. We then compare the results obtained via the one-step estimation to the two-step output. The two methods have also been compared by Camacho, Perez-Quiroz, Poncela (2012), who showed that the one-step method is preferable to the two-step one, although its marginal gains diminish as the quality of the indicators increases and as more indicators are used to identify the non-linear signal. Their result was illustrated on four series of the Stock-Watson coincident index for the US. Therefore, the first contribution of the present paper is the comparison of the two methods realized on French data. Secondly, we decrease the degree of subjectivity regarding the choice of variables for the one-step method by testing all possible combinations of 25 main economic indicators. This is a contribution relative to existing works on the alternative economic cycle chronologies for France by Kaufmann (2000), Gregoir, Lenglart (2000), Kholodilin (2006), Chen (2007), Chauvet, Yu (2007), Dueker, Sola (2008), Darné, Ferrara (2011).

The structure of the paper is as follows: in the second section we describe the baseline Markov Switching Dynamic Factor model and its two estimation methods. In the third section we discuss the dataset and the measures of quality that we use to compare the approaches. The fourth section is devoted to the description of one-step and two-step estimation results and to their comparison. Section 5 concludes.

2 The model and the methods

Assume that the growth rate cycle of the economic activity has only two regimes, associated with its low and high levels. The economic activity is unobservable and represents the common part of several observable variables, and is used to identify the most likely state at each point of time. We also assume that the switch between states happens instantaneously, without any transition period, which is considered by STAR family models. We motivate the use of Markov Switching models by the fact that the transition period before profound crises is normally short enough to be omitted. For example, the growth rate of French GDP fell from 0,5% in the first quarter of 2008 to -0,51% in the second quarter of the same year, and furher down to -1,59% in the first quarter of 2009[5].

We adopt a multivariate Markov switching factor model first described by Kim, Yoo (1995) and used as a basis in most of the papers on Markov Switching for growth rate cycle turning points detection. The model assumes that the information contained in a small number of economic indicators can be summarized in the dynamics of a latent variable (the factor). More precisely, each series can be decomposed into the sum of a common component (the factor) and an idiosyncratic component, and the factor reflects the comovements of this set of economic indicators. The model is written as:

$$y_t = \gamma f_t + z_t, \tag{1}$$

where y_t is a $N \times 1$ vector of economic indicators, f_t is a univariate common factor, z_t is a $N \times 1$ vector of idiosyncratic components, γ is a $N \times 1$ vector.

The factor f_t is supposed to follow an autoregressive Markov Switching process with constant probabilities. As we have mentioned before, we consider the case where the economy has only two states, with the high level of constant corresponding to the expansion state and the low level to the recession state and following an autoregressive process with a lag polynomial $\phi(L)$. Following Kim, Yoo (1995), we suppose that $\phi(L)$ is of order 2:

$$f_t = \beta_{S_t} + \phi_1 f_{t-1} + \phi_2 f_{t-2} + \eta_t, \tag{2}$$

where $\eta_t \sim i.i.d.\mathcal{N}(0,1)$, and ϕ_1 and ϕ_2 are the autoregressive coefficients. We don't put any restrictions on the duration of each state (as it is done in the Bry-Boschan algorithm), and characterize the states pointwise, *i.e.* a recession period may last one month only.

The idiosyncratic component z_t follows an autogressive process with a lag polynomial $\psi(L)$. In the same way, we suppose that the order of the polynomial $\psi(L)$ is 2:

$$z_t = \psi_1 z_{t-1} + \psi_2 z_{t-2} + \varepsilon_t, \tag{3}$$

where $\varepsilon_t \sim \mathcal{N}(0, \Sigma)$, and ψ_1 and ψ_2 are diagonal matrices of coefficients. The innovations ε_t are considered to be mutually uncorrelated at all leads and lags and the covariance matrix Σ is diagonal.

The switching mean is defined as:

$$\beta_{S_t} = \beta_0(1 - S_t) + \beta_1 S_t, \tag{4}$$

[5]INSEE, France, Gross Domestic Product, Total, Contribution to Growth, Calendar Adjusted, Constant Prices, SA, Chained, Change P/P

where S_t follows an ergodic Markov chain, *i.e.*

$Pr(S_t = j|S_{t-1} = i, S_{t-2} = k, ...) = P(S_t = j|S_{t-1} = i) = p_{ij}$.
Thus, S_t switches states according to transition probabilities matrix defined as $\begin{bmatrix} p_{00} & 1-p_{00} \\ 1-p_{11} & p_{11} \end{bmatrix}$,
where $P(S_t = 0|S_{t-1} = 0) = p_{00}$.

In order to build the likelihood function, we cast the model into state-space form:

$$y_t = B\alpha_t, \tag{5}$$

$$\alpha_t = T\alpha_{t-1} + \mu_{S_t} + Rw_t, \tag{6}$$

where α_t is the state variable,
$\alpha_t = (f_t, f_{t-1}, z_t', z_{t-1}')'$, with $z_t = (z_{1t}, ..., z_{Nt})'$
$w_t = (\eta_t, \varepsilon_t')'$, with $\varepsilon_t = (\varepsilon_{1t}, ..., \varepsilon_{Nt})'$
$E(w_t w_t') = Q = diag\{1, \sigma_1^2, ..., \sigma_N^2\}$,
$\mu_{s_t} = (\beta_{s_t}, 0'_{(2N+1)\times 1})'$
and B, T and R are corresponding coefficient matrices.

More explicitly, the state-space model takes the form:

$$y_t = \begin{pmatrix} \gamma & 0 & I_N & 0 \end{pmatrix} \begin{pmatrix} f_t \\ f_{t-1} \\ z_t \\ z_{t-1} \end{pmatrix}, \tag{7}$$

$$\begin{pmatrix} f_t \\ f_{t-1} \\ z_t \\ z_{t-1} \end{pmatrix} = \begin{pmatrix} \phi_1 & \phi_2 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & \psi_1 & \psi_2 \\ 0 & 0 & I_N & 0 \end{pmatrix} \begin{pmatrix} f_{t-1} \\ f_{t-2} \\ z_{t-1} \\ z_{t-2} \end{pmatrix} + \begin{pmatrix} \beta_{s_t} \\ 0 \\ 0 \\ 0 \end{pmatrix} + \begin{pmatrix} 1 & 0 \\ 0 & 0 \\ 0 & I_N \\ 0 & 0 \end{pmatrix} \begin{pmatrix} \eta_1 \\ \varepsilon_t \end{pmatrix}. \tag{8}$$

Formulas of the Kalman filter can be written conditionally to the realizations of the state variable at time t and $t-1$. If $X_{t|t-1}^{(j,i)}$ denotes the predicted value of the variable X_t conditional on the information available up to $t-1$ and on the realizations $S_t = j$ and $S_{t-1} = i$, the Kalman filter formulas are as follows:
Prediction step:

$$\alpha_{t|t-1}^{(j,i)} = T\alpha_{t-1|t-1}^{(i)} + \mu_{S_t}^{(j)}, \tag{9}$$

$$P_{t|t-1}^{(j,i)} = TP_{t-1|t-1}^{(i)}T' + RQR', \tag{10}$$

Error step:

$$v_{t|t-1}^{(j,i)} = y_t - B\alpha_{t|t-1}^{(j,i)}, \tag{11}$$

$$Var(v_{t|t-1}^{(j,i)}) = H_{t|t-1}^{(j,i)} = BP_{t|t-1}^{(j,i)}B', \tag{12}$$

Updating step:

$$\alpha_{t|t}^{(j,i)} = \alpha_{t|t-1}^{(j,i)} + K_t^{(j,i)} v_{t|t-1}^{(j,i)}, \tag{13}$$

$$P_{t|t}^{(j,i)} = (I_{(2N+2)} - K_t^{(j,i)} B) P_{t|t-1}^{(j,i)}. \tag{14}$$

The Kalman gain $K_t^{(j,i)}$ is given by

$$K_t^{(j,i)} = P_{t|t-1}^{(j,i)} B' (H_{t|t-1}^{(j,i)})^{-1}. \tag{15}$$

The conditional loglikelihood function for the sample can then be computed and estimated with the MLE:

$$\mathscr{L}(\theta|y_T) = ln(f(y_T, y_{T-1}, ..., y_0|I_T, \theta) = \sum_{t=1}^{T} ln(f(y_t|I_{t-1}, \theta)), \tag{16}$$

where $\theta = (\phi_1, \phi_2, diag(\psi_1), diag(\psi_2), \gamma, \sigma_1^2, ..., \sigma_N^2, \beta_0, \beta_1, p_{00}, p_{11})'$ is the vector of unknown parameters, the function $f(.)$ is the gaussian density function, and I_t is the information set available at the point t.

Then, the filtered probability of being in state $j \in \{0; 1\}$ in period t conditional on the information available up to t, $Pr(S_t = j|I_t, \theta)$, can be obtained using the Bayes theorem:

$$Pr[S_t = j|I_t] = \sum_{i=0}^{1} Pr[S_t = j, S_{t-1} = i|I_t, \theta] \tag{17}$$

where

$$\begin{aligned} Pr[S_t = j, S_{t-1} = i|I_t, \theta] &= \frac{f(y_t, S_t = j, S_{t-1} = i|I_{t-1}, \theta)}{f[y_t|I_{t-1}, \theta]} \\ &= \frac{f(y_t|S_t = j, S_{t-1} = i, I_{t-1}, \theta) \times Pr[S_t = j, S_{t-1} = i|I_{t-1}, \theta]}{f[y_t|I_{t-1}, \theta]} \end{aligned} \tag{18}$$

$$\begin{aligned} f(y_t|S_t = j, S_{t-1} = i, I_{t-1}, \theta) &= (2\pi)^{-N/2} |H_{t|t-1}^{(j,i)}|^{-1/2} \\ &\times exp\{-\frac{1}{2}(y_t - B\alpha_{t|t-1}^{(j,i)})\prime (H_{t|t-1}^{(j,i)})^{-1} (y_t - B\alpha_{t|t-1}^{(j,i)})\} \end{aligned} \tag{19}$$

$$Pr[S_t = j, S_{t-1} = i|I_{t-1}, \theta] = Pr[S_t = j|S_{t-1} = i, \theta] \times Pr[S_{t-1} = i|I_{t-1}, \theta] \tag{20}$$

$$f(y_t|I_{t-1}, \theta) = \sum_{j=0}^{1} \sum_{i=0}^{1} f(y_t, S_t = j, S_{t-1} = i|I_{t-1}, \theta), \tag{21}$$

The filtered probability is calculated recursively and is initialized with steady state probability of being in state $j \in \{0;1\}$ in period 0:

$$Pr[S_0 = 1|I_0, \theta] = \frac{1-p_{00}}{2-p_{00}-p_{11}}, \tag{22}$$

$$Pr[S_0 = 0|I_0, \theta] = 1 - Pr[S_0 = 1|I_0, \theta] \tag{23}$$

As we mentioned above, the model can be estimated by MLE. There are two ways to do it: either in one-step, *i.e.* to estimate the factor and the parameters simultanueously via Kim's filter (Kim (1994)), initially designing the factor so that it follows a non-linear dynamics; or in two-steps, estimating the factor first with the help of, for instance, principal component analysis, and plugging it into the model to estimate the parameters afterwards.

2.1 One step estimation

When the factor dynamics is unknown, the best estimate of the factor in case of 2 regimes and T periods would be its expected value, *i.e.* the probability weighted average of all possible 2^T paths of the factor. However, in this case the calculations become very cumbersome. In order to optimise the computation time, we use the filter by Kim (1994), which consists of collapsing the dimension of possible paths of $\alpha_{t|t}$ and $P_{t|t}$ to two on each step t by taking weighted averages over states at $t-1$, so $\alpha_{t|t}$ and $P_{t|t}$ are approximated as[6]:

$$\alpha^j_{t|t} = \frac{\sum_{i=0}^{1} Pr[S_{t-1} = i, S_t = j|I_t, \theta]\alpha^{(j,i)}_{t|t}}{Pr[S_t = j|I_t, \theta]}, \tag{24}$$

$$P^j_{t|t} = \frac{\sum_{i=0}^{1} Pr[S_{t-1} = i, S_t = j|I_t, \theta](P^{(j,i)}_{t|t} + (\alpha^j_{t|t} - \alpha^{(j,i)}_{t|t})(\alpha^j_{t|t} - \alpha^{(j,i)}_{t|t})')}{Pr[S_t = j|I_t, \theta]}. \tag{25}$$

Within the one-step method, the unknown parameters and factors are estimated simultaneously with the help of numerical search algorithms[7]. Therefore, this method may be relatively costly in terms of time and has serious limitations on the number of series included into the model. For instance, the use of four classic series (industrial production index, employment, retail sales and real income of households) already implies estimation of 22 parameters. Every additional series brings at least four more coefficients to estimate, which extends the estimation time and increases the complexity of the optimal point search. For this reason, we just use four series (as it was done by Kim, Yoo (1995) and as it is often done in case of one-step estimation). To insure the convergence of the optimal point algorithm, we also assume that the switch happens in the constant only as described in (2), and the transition probabilities are time-independent[8].

[6] For further details see Kim (1994)

[7] For our estimations we used Nelder-Mead simplex direct search with maximum function evaluations set to 2000, and tolerance for both function and dependent variables set to 0,001. We set the initial values of the parameters to the estimates of the same state-space model but without switch, *i.e.* the estimates of Stock and Watson (1989) DFM. The latter is, in turn, initialized with the OLS estimates of the system of equations where the first principal component is used as a proxy for the latent common component.

[8] Kim, Yoo (1995) showed that although the assumption of the time dependent probabilities improves the quality of the model, the gain in terms of loglikehood is not very large.

A very important feature of this method is that the growth rate cycle can be described as a common component of just a few series. So the choice of variables is essential. It is not obvious that the 4 series that worked well for the US (see Kim, Nelson (1998) and others) will perform properly for the European countries due to the differences both in data collection and the structure of the economies. To avoid subjectivity and possible effects of series selection algorithm as much as possible, we have chosen 25 indicators on the real economy, the financial sector and the perception of the economic situation, and estimate the model on all possible combinations of them.

2.2 Two step estimation

As we have already mentioned above, the algorithm of the two-step estimation is the following:

1. The factor f_t is extracted from the database of economic indicators as in equation (1) without taking the Markov-Switching dynamics into account. Here we use principal component analysis and consider the first principal component to be a good proxy, as it is a consistent estimator for the factor.
2. The first principal component is supposed to satisfy equations (2) and (4). Thus the univariate Markov-Switching model of Hamilton (1989) is fitted on this estimated factor. The parameters of the model are then estimated via MLE, where the loglikelihood function is:
$$ln\, f(f_T, f_{T-1}, ..., f_0|I_T, \theta) = \sum_{t=1}^{T} ln\, f(f_t|I_{t-1}, \theta) \tag{26}$$
3. The filtered probability is calculated as in (17).

It is important to note that principal component analysis is not necessarily the best way to extract the factor on the first step. In particular, the two-step estimator based on Kalman filtering or the QML estimator which have been proposed by Doz *et al.* (2011, 2012) seem promising as they allow for mixed frequency, missing data, and data with ragged ends.

There are two advantages of the two-step method relative to the one-step method. The first one is that it allows to consider a large amount of series. Here we take the first principal component of 151 series of economic indicators concerning the production sector, financial sector, employment, households, banking system, perception of the economy, international trade, monetary indicators, major world economic indicators and others. The second advantage is that, with the factor already estimated in the first step, there are much less unknown parameters. This allows to change the specification of the model and to introduce additional switching parameters, for example, replacing σ_η by $\sigma_{\eta S_t}$.

3 Data, reference dating and quality indicators

3.1 The dataset

Our database for the two-step procedure is constructed on a similar basis as the database used by Stock and Watson (2010) for the US and Bessec, Doz (2012) for France. It contains 151 monthly series spanning the period May 1993 - March 2014[9]. The data cover the information on production

[9]The trade-off between the sample size and the number of cross-sections made us restrict the dataset to just 11

sector, financial sector, employment, households, banking system, business surveys, international trade, monetary indicators, major world economic indicators and other indicators. All series are seasonnally adjusted, tested for the presence of unit root and differenced if it is present, then centralized and normalized.

As we are restricted with the number of series we can use for the one step method, we select 25 series out of the 151 series of the initial database. The selection was made on the basis of existing literature where the one-step method was applied for business cycle analysis. To the four classical indicators for business cycle dating of the US economy (total personal income, total manufacturing and trade sales, number of employees on nonagricultural payrolls, total industrial production index) we add series used in Kholodilin (2006) (French stock market index CAC40, interest rates on the 3 months and 12 months government bonds, imports and exports), selected series of business surveys, proved to be useful by Bessec, Doz (2013), the components of the OECD Composite Leading Indicator, as well as several series characterizing the dynamics of the major trade partners (Germany, the USA, Asia). Since the algorithm is not able to process all 25 series altogether, the series are taken in combinations by four, overall $C_{25}^4 = 12650$ combinations.

Detailed lists of series for both methods are given in Tables A.1 and A.2 of Appendix A.

3.2 Reference dating

In order to measure the quality of the results of each of the two methods, we need to compare it to some reference business cycle chronology. The choice is not evident, as the existing datings provide different sets of turning points. To our knowledge, there exist at least three open source reference dating chronologies for the European countries: OECD[10], CEPR[11] and ECRI[12]. Figure 1 below shows that these chronologies indeed do not coincide in the starting and the final points of recessions and in the duration of economic cycle phases. Moreover, OECD states a recession during April 1995 - January 1997 which other institutions do not identify.

The difference obviously lies in the methodology of turning point identification and in the data taken into consideration. The OECD dating is the output of the Bry-Boschan algorithm applied to the Composite Leading Indicator (CLI), which is an aggregate of a fixed set of 9 series (components of the leading indicator), highly correlated to the reference series (industrial production index or GDP series). The turning point chronologies of CEPR are obtained from the balance of expert opinions on the basis of series selected by the experts involved. The ECRI index is the output of an undisclosed statistical tool on the undisclosed (but probably the most information-rich) dataset.

Although each methodology has its weak and strong points, we take the OECD dating as a benchmark as it relies on a clear and replicable algorithm. We thus adopt the definition of the economic cycle as the movement of the cyclical component of GDP and implicitly the comovement

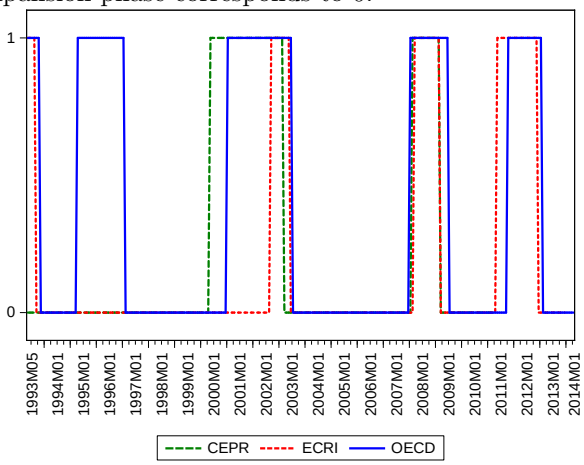
years of observations. A longer period (starting with 1990) would reduce the number of cross-sections to 97, while the full original balanced database (213 series) starts in February 1996.

[10] http://stats.oecd.org/mei/default.asp?rev=2

[11] http://www.cepr.org/content/euro-area-business-cycle-dating-committee

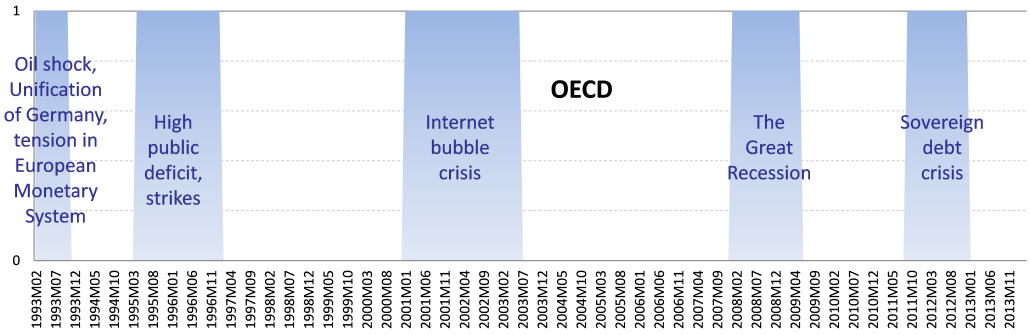
[12] https://www.businesscycle.com/

Figure 1: Economic cycles chronologies according to OECD, ECRI and CEPR. The recession phase corresponds to 1, the expansion phase corresponds to 0.



of 9 monthly components of the CLI, that constitutes the basis for the final turning point dating.[13] So, the time sample that we consider covers 5 crises in the French economy as determined by OECD (see Figure 2):

Figure 2: OECD reference turning points for the French economy, 1993-2013



Note: 1 corresponds to recession, 0 - to expansion

[13]The CLI components are: 1. New passenger car registrations (number) 2. Consumer confidence indicator (% balance) 3. Production (Manufacturing): future tendency (% balance) 4. SBF 250 share price index (2010=100) 5. CPI Harmonised All items (2010=100) inverted 6. Export order books (Manufacturing): level (% balance) 7. Selling prices (Construction): future tendency (% balance) 8. Permits issued for dwellings (2010=100) 9. Expected level of life in France (Consumer Survey) (% balance). All series are detrended, and seasonally, calendary and noise-adjusted. They are selected so that they have a cycle pattern similar and coincident (or leading) to the one of the reference series. Until April 2012 the industrial production index was taken as a reference series, replaced by monthly estimates of GDP growth afterwards.

- March 1992 - October 1993: the crisis, caused by the oil shock following the first Gulf War, German reunification and tensions in European Monetary system;
- April 1995 - January 1997: rather a slowdown in economic growth rates than a real recession, with only one quarter of slightly negative (-0,011) growth rate, caused by the decrease of high public deficit and the consequent strikes throughout the country;
- January 2001 - June 2003: the Internet bubble crisis;
- January 2008 - June 2009: the Great Recession, the global financial crisis;
- October 2011 - January 2013: the sovereign debt crisis.

The OECD choronology is updated each quarter only, so if one is interested in the estimate of the current state of an economy in January, he will have to wait until the OECD dating is updated in April. As the MS-DFM allows to obtain the estimates much faster, in what follows we compare the timing associated to the one-step and two-step methods to the timing of OECD.

It can be argued that the chronologies on the basis of the Bry-Boschan procedures contain too many arbitrary parameters, and should be used as a reference with caution. However, we support our choice by the fact that the OECD chronology is the closest to datings calculated by INSEE[14]. Although INSEE has no official turning point chronology, in the working paper by Bardaji *et al.* (2008) and in a similar paper Bardaji *et al.* (2009), the authors used the dating on the basis of the cyclical component of GDP extracted with Christiano-Fitzgerald filter as a reference. We reproduce this work and estimate the chronology on the basis of monthly data of industrial production index (as well as quarterly GDP series): the dating we obtain is indeed very close to OECD results. In the same time, it is rather close to the dating obtained by Anas *et al.* (2007) for Eurostat (see Figure 3).

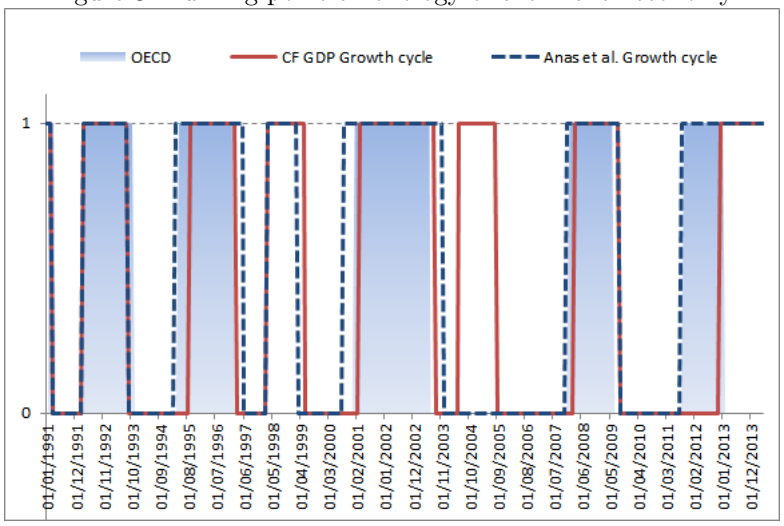
It could also be argued that OECD dating (as well as INSEE datings) can not be used as a reference because they represent the chronologies of the growth cycle, whereas we use MS-DFM to identify the growth rate cycle. Indeed, in order to achieve stationarity in data we use it in differences of logarithms. In our exercise, we intentionally avoid the problem of the cyclical component extraction as it implies additional complications inherent to the definition of a trend. Nevertheless, we argue that OECD dating can still be used since during the latest 25 years these two cycles tend to be very close.

Note that the dating obtained on the basis of Christiano-Fitzgerald filter has two additional recessions (in 1998-1999 and 2004-2005) that are not present in the OECD dating. This might be due to the existence of a lower bound of recession duration inside the Bry-Boschan algorithm (15 months), which neglects short phases (which is the case in these two periods). Indeed, in both cases INSEE detected a deterioration of the economic activity due to different reasons.

According to INSEE, the signal of 1998-1999 recession was most probably explained by the decline in the net external trade of France. Undermined by the Asian and Russian crises, the external demand from Japan, China and Russia, as well as other developping Asian countries and even the UK, Belguim, Italy, fell dramatically - from 10% growth rate in 1997 to only 4% in 1998. The

[14]National Institute of Statistics and Economic Studies, France

Figure 3: Turning point chronology of the French economy



Note: 1 corresponds to recession, while 0 corresponds to expansion. A Christiano-Fitzgerald filter is applied to the series of French GDP in levels (bandwidth 6 to 40 quarters), the turning points are considered to take place in the second month of a quarter (red line). A Christiano-Fitzgerald filter is also applied to the series of French industrial production index in levels (bandwidth 18 to 120 quarters, blue line). As Bardaji *et al.*, we also restrict the minimum duration of every phase to 4 quarters or 12 months, although this restriction does not affect any of datings.

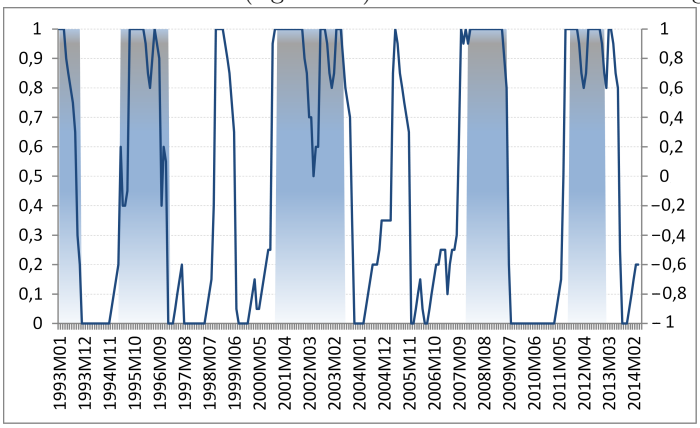
depreciation of yen and dollar contributed to the appreciation of the real effective exchange rate of franc. In general, the external balance of France decreased by 7,1% which resulted into negative contribution to the GDP growth (-0,4 pp)[15]. The producers were pessimistic about future activity (also worried about the financial crisis and reducing prices for energy and oil which threatened to turn into desinflation), decreasing their investment and limiting the inventories[16].

The recession signal of 2005 was also explained by the deceleration of the external demand due to uncertainty in the economic situation in the US and Japan caused by the oil price shock. Producers in manufacturing and service acted with caution: the prices for raw materials were rising, and euro was appreciating in real terms, the saving rate of households fell, the GDP quarterly growth was declining, too[17].

It is interesting to notice that the Reversal Index of INSEE (Indicateur de Retournement[18]) also reflects these observations, having spikes of high probability of recession in 1998 and 2005 (see Figure 4).

[15]INSEE PREMIERE, N°659 - June 1999
[16]INSEE CONJONCTURE, Note de conjoncture, December 1998
[17]INSEE CONJONCTURE, Note de conjoncture, Mars 2005
[18]L'Index de Retournement is the index comprised between -1 and 1 which shows the difference between the probability to be in expansion in the current period and the probability to be in recession in the current period. The index is based on the business surveys about the current, past and future perceptions of the economic situation.

Figure 4: The index of reversal (right axis) and OECD reference dating (left axis)



3.3 Measures of quality

The proposed one-step and two-step procedures are valid if they are able to reproduce turning points chronology of some reference dating, for example, by OECD Dating Committee. To assess the quality of match we use two popular indicators:

- **Quadratic probability measure.** This indicator shows the average error of filtered probability as an average quadratic deviation from the reference dating. The higher QPS is, the lower is the quality of fit.

$$QPS = \frac{1}{T}\sum_{t=1}^{T}(RD_t - Pr[S_t = 1|I_t])^2$$

  where T is the number of periods in the sample, RD_t is the reference dating series of 0 and 1 (1 corresponding to recession, 0 to expansion), and $Pr[S_t = 1|I_t]$ is the filtered probability of being in recession in period t.
- **False positives.** This indicator counts the number of wrongly predicted periods. Here we set the threshold probability on the intuitive level of 0,5.

$$FPS = \sum_{t=1}^{T}(RD_t - I_{Pr[S_{t=1}|I_t]>0,5})^2$$

  where $I_{Pr[S_{t=1}|I_t]>0,5}$ is the indicator function equal to 1 if the estimated filtered probability if higher than 0,5 (determines recession) and 0 otherwise. The lower FPS is, the more qualitatively accurate is the model.

4 Estimation results

4.1 One-step method

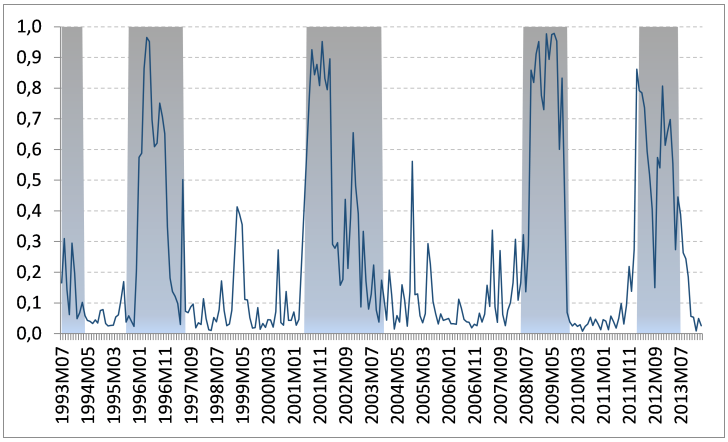
Informative series

The estimation over 12650 combinations did not produce 12650 outputs as for most of the combinations the convergence was not achieved, or the series combination produced a factor that does not have a nonlinear structure, or the results were invalid due to the parameter values that produced nonstationary dynamics of the factor. Therefore, only 575 combinations achieved convergence, and only 424 of them have interpretable filtered probabilities. Out of this number, we have retained 72 results that are informative in terms of signals of past recessions. We will refer to the combinations by the number that they were initially attributed (from 1 to 12650).

We construct the frequency rating of economic series (given in Table B.1 of Appendix B) for the integrity of all interpretable results of the one-step estimation. Some series turned out to have weak explanatory content, such as CPI index or CAC-40 financial index, the latter entering none of successful combinations. Others did much better: construction confidence indicator, capacity utilisation, exports, retail trade confidence index and unemployment rate appear each in 22, 21, 20 and 19 combinations, respectively. This allows us to suggest that the contribution of these indicators is important for the final aggregate factor to follow a bi-state dynamics. Note that CPI and the stock market index both enter the OECD CLI, although they seem to be not very informative for the turning points detection in our framework.

To illustrate the results that we considered as interpretable, we present the output of the combination #9982 on Figure 5. It consists of the 4 most frequent indicators that we mentioned above: unemployment rate, exports, retail trade and construction confidence indicator. The resulting filtered probability is one of the best in terms of fit to the OECD official dating.

Figure 5: The result of 1step estimation for the combination 9982: the filtered probability of recession (blue line) and the reference dating (shaded area, OECD, 1 corresponds to recession state).

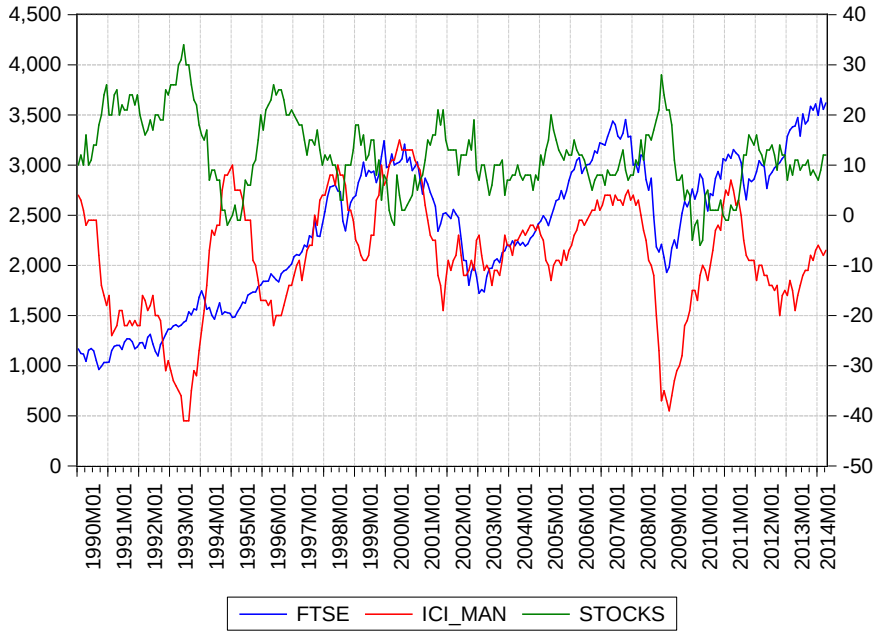


As we can see from this figure, this combination produces a factor probability that captures 4 out of 5 crises if we consider the economy to be in recession if the filtered probability of a recession is higher than 0,5. One can notice two important drawbacks of this example: first, there is an extra signal in 2004; second, not all the crises are explained equally well. These pitfalls are frequently present in the other outcomes, so we discuss each of them in turn.

Extra signals

In general, out of 72 combinations only 27 do not produce any extra signals of recession that are not present in the reference dating. The other 45 combinations give an additional alert in the end of 1998, or another one around mid-2005, or both. Among the series with the highest loadings that appear relatively more often in such combinations than in the other ones are manufacturing finished goods stocks level, price return on FTSE equity index and Manufacturing Industrial Confidence Indicator. Indeed, we can see that all three series underwent significant downturn in 1998-1999, while in 2005 stocks of manufacturing finished goods and manufacturing confidence index fell back to the levels of the end of the Internet bubble crisis (see Figure 6). However, these events are not captured by the OECD dating.

Figure 6: False signals suspects: FTSE 100 , All-Share, Index, Price Return, End of Period, GBP (left axis), Manufacturing Finished Goods Stocks Level (right axis), Manufacturing Industrial Confidence Indicator (right axis)



As we have mentioned above, these signals are not false in the sense of producing a false alert of recession when the economy is actually growing, but they correspond to effective deterioration of economic conditions. However, in order to develop an instrument that would allow to replicate OECD dating precisely, these extra signals should be avoided. The one-step approach allows to do so, since one can exclude the series that are likely to produce extra signals from the dataset [19].

Different set of series for different crises

As for true recessions, it is important to keep in mind that none of them (at least the 5 recessions we consider here) had the same origins as the other, so it is possible that the determinants of economic activity evolved with time, and thus it is possible that the common factor of a particular set of series does not perceive the Great recession as well as it reflected the crisis of 1992-1993. However, in order to construct a universal instrument, it is preferable to find series that would capture the recession in all cases, if possible. For this purpose we compare the quality indicators of 72 sets of variables for each crisis separately. The Table B.2 in Appendix B summarizes the information on the best combinations by crisis. Here FPS stands for false positives and shows the proportion of months of each crisis incorrectly determined as expansion, *i.e.* the lower FPS is, the better a crisis is captured.

We can see that:

- the combination 8816 (the volume of total retail trade, unemployment rate, trade balance and order books in the building industry, with the highest loadings on unemployment (8)) is the best to describe the probability of the first and the last crisis and captures the second crisis almost as well as two other combinations.
- the combination 3913 (new passenger cars sales and registration, retail trade orders intentions, export, confidence indicator in services, with the highest loadings on retail trade (4) and Confidence Index in services (24)) is leading in case of the second, the third and the fourth crises, being significantly superior to the other combinations for the third and the fourth recessions.
- Although good on certain periods of the timeline, unfortunately none of these sets of variables could be used as a 'core' set due to their relatively poor performance on the expansion periods and non-detected crises.

The set of data contained in these 2 combinations appears to be sufficient to identify all 5 crises with a special role given to unemployment, retail trade orders intentions and confidence index in services.

The finally selected information set

Considering the observations on the effects of different series on the final filtered probability, we conclude that a good information set would:

1) contain the series that enable us to determine all the 5 crises

[19] Interestingly, Bruno and Otranto (2004) also find similar signals of 1998-1999 and 2005 for the chronology of the Italian economic cycle. They note that these signals appear when the dating is produced by direct methods, *i.e.* on the basis of a common factor, while the dating on the basis of aggregated individual chronologies (as is the case of OECD dating) does not produce them.

2) not contain the series that produce extra signals
3) perform well in general in terms of QPS and FPS

The top 25 combinations with the lowest QPS and FPS measures are given in Table B.3 in Appendix B. The first eight are in the lowest 10% by both indicators, so 7 of them (we exclude the combination #3394 because of the presence of extra signals) could be candidates for the 'core' sets of economic indicators that enable to replicate the OECD dating. The graphs of corresponding 7 filtered probabilities are given in Figure B.1 of Appendix B.

It is not surprising that there are several 'best' sets of variables, as the restriction of the model to comprise only 4 series into the model is just a technical limitation, and the factor matching the dynamics of the GDP growth of the economy is determined by much more series. The analysis of the factor loadings of these 7 combinations can give us an idea of the economic indicators that play the most important role in dating of GDP growth series. According to our estimations, the heaviest factor loadings belong to (see Table B.3 in Appendix B):

— 4 - France, OECD MEI (Enquete de Conjoncture INSEE), Retail Trade Orders Intentions, SA;
— 8 - France, INSEE, Metropolitan, Unemployment, Job Seekers, Men, Total, Categories A, B & C, Calendar Adjusted, SA
— 19 - France, OECD MEI (Enquete de Conjoncture INSEE), Manufacturing Business Situation Future, SA
— 24 - France, Business Surveys, DG ECFIN, Construction Confidence Indicator, Balance, SA

The first two of these indicators were also determined as components of the Growth Cycle Coincident indicator by Anas *et al.* (2008).

Among the other indicators contributing to the factors in the 7 selected combinations are:

— 2 - France, Consumer Surveys, INSEE, Consumer Confidence Indicator, Synthetic Index, SA
— 3 - France, INSEE, Domestic Trade, Vehicle Sales & Registrations, New, Passenger Cars, Total, Calendar Adjusted, SA
— 7 - France, OECD MEI, INSEE, Total Retail Trade (Volume), SA, Change P/P
— 9 - France, OECD MEI, INSEE, Manufacturing Finished Goods Stocks Level, SA
— 11 - France, INSEE, Foreign Trade, Trade Balance, Calendar Adjusted, SA, EUR
— 12 - France, INSEE, Foreign Trade, Export, Calendar Adjusted, SA, EUR
— 17 - Japan, Economic Sentiment Surveys, ZEW, Financial Market Report, Stock Market, Nikkei 225, Balance
— 18 - United States, Equity Indices, S&P, 500, Index (Shiller), Cyclically Adjusted P/E Ratio (CAPE)
— 23 - France, Service Surveys, DG ECFIN, Services Confidence Indicator, Balance, SA

In order to overcome the problem of limited use of data, we attempt an estimation of the one-step method on the 13 series above, *i.e.* on the whole selected information set, listed above. Unfortunately, the optimisation algorithm did not acheive convergence while searching for likelihood maximizing set of parameters, although, with the parameters set on their initial values, the filtered probability calculated at the initial values of parameters (obtained with OLS) captures all the five crises without detecting any extra recessions, as expected (see Figure B.2 in Appendix B). We

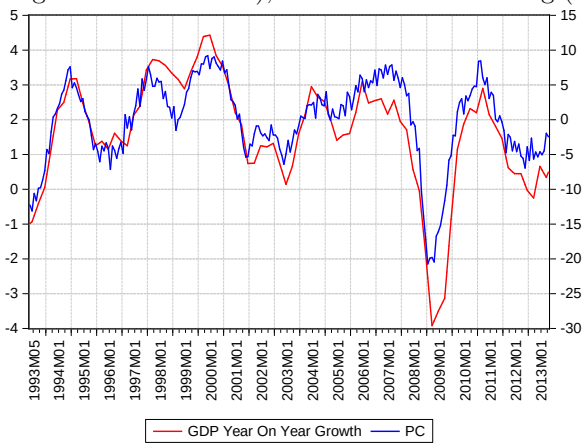
also attempted a one-step estimation on the 9 components of OECD CLI, and the results that we managed to obtained (the algorithm converged only on a certain subsample) contain much more extra signals than before, with the beginnings and the ends of business cycle phases determined with much less precision. Both these observations confirm that inclusion of too many unknown parameters may result into convergence problems, and thus the number of series is technically limited for the one-step method. Therefore, since it seems unfeasible to use the information contained in the abovelisted 13 series simultaneously within one-step approach, the results of the 7 combinations should be used as complements.

4.2 Two-step method

First step: PCA

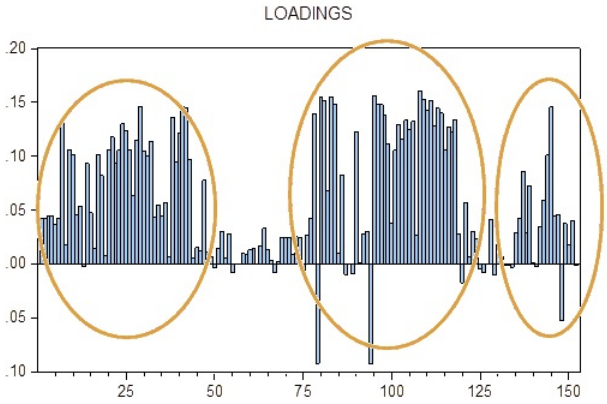
On the first step of the procedure we extract the first factor by principal component analysis. The first principal component that we use as a proxy for the factor in the two-step method describes 23,43% of the total variance which is quite reasonable when considering the size and heterogeneity of the database. The dynamics of the first component and the factor loadings are presented below in Figure 7 and Figure 8. One can note that it is close to the dynamics of GDP growth, so the factor is relevant. Indeed, the correlation on the whole sample is equal to 0,91, while the correlation on the shorter period ending in December 2007 to eliminate the impact of the Great Recession is 0,895.

Figure 7: Filtered probability of recession, the two step-estimation (switches in constant and variance, non-switching autoregressive coefficients), OECD reference dating (shaded areas)



Note: the solid line corresponds to the dynamics of the first principal component of the full dataset (left axis), the dashed line corresponds to the French GDP growth series (left axis). The quarterly GDP growth series were converted into monthly series via linear interpolation.

Figure 8: The values of the eigenvector of the first principal component



The three heaviest groups of weights in the first component correspond to (in circles, from left to the right): 1) production and consumption series, disaggregated; 2) business surveys; 3) series on the world economy.

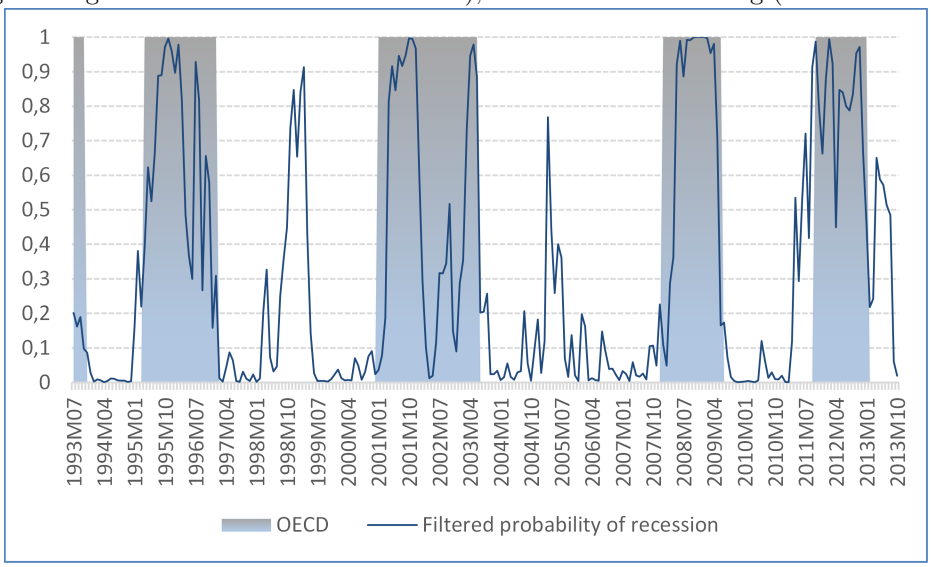
The three groups of the heaviest weights in the first component correspond to: 1) production and consumption series, disaggregated; 2) business surveys; 3) series concerning the world economy. The first component therefore captures the present and expected behavior of firms and households and the impact of foreign economies and pays less attention to the banking and financial sector, monetary aggregates, balance of payments and currency indicators.

Second step: estimation of a Markov-Switching model

Basic specification, a switch in mean only.

On the second step of the two-step estimation procedure we estimate a Markov-switching model as defined in equation (2) of the model, with the unobservable factor replaced by the first principal component estimated on the first step. The results are quite satisfactory, with the filtered probabilities capturing all the crises well (but the first one) and without sizable leads and lags (see Figure 9). As expected, the estimations provide a positive constant for the expansion periods, and a negative one for recessions: $\mu_0 = 1,04$, $\mu_1 = -1,77$, respectively (the estimates are significant at 1% level of significance). For this specification, $QPS = 0,1278$ and $FPS/T = 0,1872$, and the average lag of the identification of the beginning of recession is 0,75 months, while the end of recession is detected 1 month earlier). Note that this result already outperforms the best result of our one-step estimations.

Figure 9: Filtered probability of recession, the two step-estimation (switches in constant, non-switching autoregressive coefficients and variance), OECD reference dating (shaded areas)



The extra signals of 1998-1999 and 2004-2005 are clearly detected by the first component. This may be explained by the fact that the dataset includes the series which induce extra signals for the one-step method, as well as a number of other series that experienced shocks in these periods. We did a simple exercise by trying to eliminate these series from the dataset. It turned out impossible to get rid of all extra signals without deteriorating the signals on the OECD recessions. The removal of series undermines the performance of the two-step method and deprives it of its most valuable advantage - the large scale of data. However, it is not a big disadvantage since these signals are not erroneous, as we mentioned before.

Similarly, the transitory improvement in the middle of the Internet bubble crisis and the earlier detection of the beginning of the sovereign debt crisis, omitted by OECD dating because of its temporary character, can be tracked in the INSEE reports issued soon after this period[20].

Alternative specification, switches in mean and variance.
We take advantage of the possibility to introduce switches into other coefficients of the model to check whether it will bring to enhanced detection of the turning points. Now we let the variance

[20]INSEE observed the enhancement of the business climate in 2001 primarily due to the subjective perception that the US have passed the trough of the business cycle, rebound growth in Asia, Germany and the negative oil price shock improved the expectations of investors and entrepreneurs, while the decrease in taxes gave an extra stimulus for household consumption, increasing their purchasing power (INSEE CONJONCTURE, Note de conjoncture, Mars 2002). The reasons for early peaks in 2011 are the deterioration of business climate in France, seism in Japan, anti-inflation policies in developing countries, as well as budget consolidation policy in the developed countries, positive price shocks for commodities (oil included) increased production costs. All this led to a certain pessimism among French investors (Point de conjuncture October 2011, INSEE).

of the error term in the factor dynamics to be state specific, too, so the model of factor dynamics becomes:

$$f_t = \beta_{S_t} + \phi_1 f_{t-1} + \phi_2 f_{t-2} + \eta_{S_t}, \tag{27}$$

where $\eta_{s_t} \sim N(0, \sigma^2_{S_t})$. While as performative on average ($QPS = 0,1278$), ($FPS/T = 0,1832$) as the basic specification, the alternative specification is slightly better in capturing the beginnings and ends of recessions (the identification lag is 0 and 1 months on average, respectively)[21]. As before, the estimations provide a positive constant for the expansion period, and a negative one for recessions $\mu_0 = 1,22$, $\mu_1 = -1,52$. The volatility of the factor dynamics is estimated to be almost two times higher during recessions ($\sigma_0 = 0,4$, $\sigma_1 = 0,75$). The estimates of the other parameters are given in Table C.1 in Appendix C. Again, the filtered probabilities produced by this specification capture all the crises well (but the first one) and without sizable leads and lags. The dynamics of filtered probabilities for this specification resembles the one for the basic specification, so we do not report the graph here.

4.3 Comparison: one-step vs two-step

In order to give a general comparison, we oppose the quality indicators of the two-step estimation to the *average* of 7 best outcomes of the one-step method, as we suggest that they can be complements to each other. As before, we compare the average number of false signals FPS, the average square error QPS, the timing and the average number of periods between the estimated and reference beginning (and end) of recessions (see Table 1). We also compare our results to the chronologies estimated by Kauffman (2006), Chauvet, Yu (2006), Chen (2007), Kholodilin (2006).

The two step method is more accurate in terms of average error QPS, even though it produces extra signals. The difference between the average one-step method and two-step method in both QPS and average FPS is negligible, so the average performance of the two methods is comparable. However, taking into account that the one-step method results are free of extra signals (because we managed to select the series so), this means that for the OECD recessions the two-step method is more precise. Actually, the two-step method is much more accurate with respect to the beginning and the end of recessions, with a tendency to indicate the beginning of a recession on average one quarter of a month earlier; the one-step method is late with the beginning on 2,5 months and precipitates the end 2,6 months earlier. In general, both methods produce early warning signals. For the one-step method, with the exception for the combination #9982, the data in each of the retained combinations are updated with 1 month or even 0 month lag (case #6089). This means that the current phase of the GDP growth cycle in January 2015 can be determined either in February or March 2015, with no need to wait for the release of quarterly GDP growth data in April 2015. Though the gain in time is not very big, it may still be of a great imporance for policy makers. For the two-step method, the estimates are available in two months. This is still less than the timing of OECD, although one month more than the timing of the one-step method. In this respect, the estimation of the factor on the first step with the help of one of the procedures proposed by Doz

[21] We also tried specifications with switching autoregressive coefficients and different combinations of switching parameters, but none of them are as performative. To save space, we do not report the results here, but they are available on request.

Table 1: The comparison of one-step and two-step estimation results

	QPS	FPS/T	Start lag	End lag	Timing
Two step method, switching μ	0,1278	0,1872	0,75	-1	2M
Two step method, switching μ and σ	0,1278	0,1832	0	1	2M
One step method, av	0,1346	0,1779	2,5	-2,675	1M
One step, 5820	0,1287	0,1383	0,6	0,4	1M
One step, 3394	0,1315	0,1542	0,6	-2,6	1M
One step, 3913	0,1254	0,1779	1,8	-0,2	1M
One step, 6089	0,1328	0,1818	3,4	-3,8	0M
One step, 5757	0,1412	0,1818	5,2	-4,2	1M
One step, 10233	0,1184	0,1858	3,6	-3,6	1M
One step, 9982	0,1493	0,1937	3	-8	1M
One step, 8817	0,1492	0,1976	1,8	0,6	1M
Kauffman (2000)		0,2151			
Chauvet, Yu (2006)		0,3777			
Chen (2007)		0,2839			
Kholodilin (2006)	0,152	0,3333			

Start lag - the number of lags between the estimated start of a recession and the OECD determined start; End lag - the number of lags between the estimated end of a recession and the OECD determined end; T is the number of periods in the sample

et al. (2011, 2012) is very promising since it allows to have the estimator of the factor on the available information only, without waiting until all series in the database are updated. We leave this exercise for further research.

All the estimated models give similar qualitative results in terms of the values of coefficients (see Table C.1 in Appendix C): there are two distinct regimes, which are characterized by a negative constant in the recession state and a positive constant in the expansion state. The magnitude of the differences in the two values of constants varies as the the magnitude of factors is determined by the underlying economic indicators. The transition probabilities are coherent, too. The phases of the French growth rate cycle are very persistent, with the probability to stay in expansion while being in expansion a bit higher than the probability to have two consecutive months in recession. All other estimates of the Table 2 cannot be interpreted directly as they refer to different series and are given for information.

We also performed a robustness-check exercise, estimating the model with both methods on expanding sample. Although the resulting filtered probabilities are stable when the sample is up to 50 points shorter, the convergence is not always achieved for the one-step method, which is not very convenient.

The final datings for both methods are similar in general, although some incoherences and divergence from the OECD series exists (see Table 2).

Table 2: Final dating produced by one-step procedure on 7 best sets of data, two-step procedure and OECD dating

		1step5820	1step3913	1step6089	1step5757	1step10233	1step9982	1step8817	2step	OECD
1st crisis	P							1993m02		1992m02
	T							1993m10		1993m10
2nd crisis	P	1995m07	1995m06	1995m08	1995m08	1995m09	1995m07	1995m09	1995m01	1995m03
	T	1996m12	1996m12	1996m09	1996m10	1996m10	1997m01	1997m05	1997m01	1997m01
1 false signal	P								1998m09	
	T								1999m04	
3rd crisis	P	2001m01	2001m01	2001m02	2001m01	2001m02	2001m01	2001m04	2001m03	2000m12
	T	2003m07	2003m06	2003m04	2002m11	2003m03	2002m07	2003m12	2003m09	2003m06
2 false signal	P								2005m02	
	T								2005m07	
4th crisis	P	2007m09	2007m09	2008m04	2008m04	2008m04	2008m04	2008m04	2008m04	2007m12
	T	2009m09	2009m11	2009m05	2009m06	2009m09	2009m04	2009m09	2009m08	2009m06
5th crisis	P	2011m09	2011m09	2011m09	2012m07	2012m05	2011m09	2011m06	2011m03	2011m09
	T	2013m07	2013m08	2012m10	2012m11	2013m07	2012m11	2013m07	2013m08	2013m01

5 Conclusion

The estimation of the MS-DFM on the French data shows that it is a valid instrument to date economic cycles. It allows to know the current state of the business cycle as determined by OECD one or two months before the OECD release.

Having compared the one-step and two-step estimation methods of the model, we show that both approaches produce qualitatively similar results - the common factor of several specific economic series (in case of one-step method) and the first principal component of a large set of series (in case of two-step method) can be characterized as having two distinct phases with low and high growth rates. The two-step method also allows to detect the difference in the magnitude of variance in the factor dynamics. Four out of five crises are captured by high filtered probability of recession well and on time, implying that both methods are valid for determination of turning points of the growth rate cycle in France as determined by OECD and allow to identify turning points more timely than any official dating committee, which is important for economic agents and policymakers. This result is of course to be confirmed through a pseudo real-time study, which we leave for further research.

The results of one-step method differ greatly subject to the composition of the 4 economic series that enter the model under this approach. We find the most explicative series (retail trade order intentions, number of job seekers, the survey on manufacturing business situation future and construction confidence index) and the series that produce extra signals (manufacturing finished goods stock level, price return on FTSE equity index and Manufacturing Industrial Confidence Indicator) and determine 7 sets that perform the best in terms of concordance of estimated turning points with

OECD chronology. Since the set of series considered with one-step method is limited to 4 series, it seems reasonable to use several sets (*i.e.* several results of one-step estimation) as complements to overcome the information constraint.

Using a more comprehensive dataset with two-step method allows us to obtain more accurate estimates of the beginning and the end of recessions. However, it inevietably detects short recessions (like in 1998-1999 and 2004-2005) that are omitted in OECD dating. We show that these signals are not false, as the worsening of economic situation was marked in the corresponding short term INSEE reports, as well as captured by the Index of reversal by INSEE and the datings obtained with the help of Christiano-Fitgerald filter.

We conclude that either method can be used to replicate the OECD dating. Nevertheless, we tend to give favor to the two-step method, as it allows to have a valid dating of turning points without going through a complicated procedure of series selection. On the other hand, it is much less time-consuming and the convergence problems are not frequent. Our exercise shows that when the dataset is large, the factor does not face the problem of slow response to the recent shocks (as it was shown in Camacho et al. (2011)), but is able to provide early alerts of the upcoming change of state. Another advantage of the two-step method is that is opens the way to use various estimation techniques of the factor on the first step. In this respect, further research will concern a 2-step estimator proposed by Doz *et al.* (2011) as well as the QML estimator proposed by Doz *et al.* (2012) instead of PCA. It will allow to use data of different frequences, with missing observations or ragged ends.

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Appendix A. Datasets

Table A.1. Series used for the two-step estimation

Series full name	Source	SA	Lag
Industrial production by industry			
General			
France, OECD MEI, Production Of Total Industry, SA, Change P/P	Macrobond	SA	2
France, OECD MEI, Production Of Total Industry, SA, Index	Macrobond	SA	2
France, OECD MEI, Production Of Total Manufactured Intermediate Goods, SA, Index	Macrobond	SA	2
France, OECD MEI, Production In Total Manufacturing, SA, Index	Macrobond	SA	2
France, OECD MEI, Production Of Total Manufactured Investment Goods, SA, Index	Macrobond	SA	2
France, Industrial Production, Total Industry Excluding Construction, Calendar Adjusted, SA, Index	Macrobond	SA	1
France, Capacity Utilization, Total Industry, SA	Macrobond	SA	0
Mining			
France, Eurostat, Industry Production Index, Extraction of Crude Petroleum & Natural Gas, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Other Mining & Quarrying, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Mining & Quarrying, Calendar Adjusted, Change Y/Y	Macrobond		1
Nondurables			
France, Eurostat, Industry Production Index, Manufacture of Food Products, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Beverages, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Tobacco Products, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Textiles, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Wearing Apparel, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Leather & Related Products, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Paper & Paper Products, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Printing & Service Activities Related to Printing, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Coke & Refined Petroleum Products, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Chemicals & Chemical Products, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Rubber Products, Calendar Adjusted, Change Y/Y	Macrobond		1
Durables			
France, Eurostat, Industry Production Index, Manufacture of Computer, Electronic & Optical Products, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Electric Motors, Generators, Transformers & Electricity Distribution & Control Apparatus, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Electrical Equipment, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Machinery & Equipment N.E.C., Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Motor Vehicles, Trailers, Semi-Trailers & of Other Transport Equipment, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Building of Ships & Boats, Calendar Adjusted, Change Y/Y	Macrobond		1

France, Eurostat, Industry Production Index, Manufacture of Furniture, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, Manufacturing, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Construction, Building & Civil Engineering, Construction & Production Index, Buildings, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Construction, Building & Civil Engineering, Construction & Production Index, Civil Engineering Works, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Construction, Building & Civil Engineering, Construction & Production Index, Construction, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Metropolitan, Construction by Status, Number, Permits, Residential Buildings, Total	Macrobond		1
France, Metropolitan, Construction by Status, Number, Housing Starts, Residential Buildings, Total	Macrobond		1
France, Construction by Status, Number, Permits, Residential Buildings, Total	Macrobond		1
France, Construction by Status, Number, Housing Starts, Residential Buildings, Total	Macrobond		1
Utilities			
France, Eurostat, Industry Production Index, Electricity, Gas, Steam & Air Conditioning Supply, Total, Calendar Adjusted, Change Y/Y	Macrobond		1
Industrial production by market			
Durables			
France, Eurostat, Industry Production Index, MIG - Capital Goods, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, MIG - Consumer Goods (Except Food, Beverages & Tobacco), Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, MIG - Durable Consumer Goods, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, MIG - Intermediate & Capital Goods, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, MIG - Intermediate Goods, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, MIG - Consumer Goods, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Expenditure Approach, Household Consumption Expenditure, Automobiles, Calendar Adjusted, Constant Prices, SA, EUR	Macrobond	SA	1
France, Expenditure Approach, Household Consumption Expenditure, Housing Equipment, Calendar Adjusted, Constant Prices, SA, EUR	Macrobond	SA	1
France, Expenditure Approach, Household Consumption Expenditure, Durable Personal Equipment, Calendar Adjusted, Constant Prices, SA, EUR	Macrobond	SA	1
Nondurables			
France, Eurostat, Industry Production Index, MIG - Non-Durable Consumer Goods, Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, MIG - Energy (Except D & E), Calendar Adjusted, Change Y/Y	Macrobond		1
France, Eurostat, Industry Production Index, MIG - Energy (Except Section E), Calendar Adjusted, Change Y/Y	Macrobond		1
France, Energy Production, Transmission & Distribution, Electric Power Generation, Transmission & Distribution, Calendar Adjusted, SA, Index	Macrobond	SA	1
France, Eurostat, Industry Production Index, Manufacture of Products of Wood, Cork, Straw & Plaiting Materials, Calendar Adjusted, Index	Macrobond		1
France, Eurostat, Industry Production Index, Manufacture of Basic Metals & Fabricated Metal Products, Except Machinery & Equipment, Index	Macrobond		1
France, Expenditure Approach, Household Consumption Expenditure, Textiles & Leather, Calendar Adjusted, Constant Prices, SA, EUR	Macrobond	SA	1
France, Expenditure Approach, Household Consumption Expenditure, Other Manufactured Goods, Calendar Adjusted, Constant Prices, SA, EUR	Macrobond	SA	1
France, Expenditure Approach, Household Consumption Expenditure, Energy, Water & Waste Treatment, Calendar Adjusted, Constant Prices, SA, EUR	Macrobond	SA	1

France, Expenditure Approach, Household Consumption Expenditure, Petroleum Products, Calendar Adjusted, Constant Prices, SA, EUR	Macrobond	SA	1
France, Expenditure Approach, Household Consumption Expenditure, Food, Calendar Adjusted, Constant Prices, SA, EUR	Macrobond	SA	1
France, Expenditure Approach, Household Consumption Expenditure, Goods, Calendar Adjusted, Constant Prices, SA, EUR	Macrobond	SA	1
Equipment			
France, Manufacturing, Computers & Peripheral Equipment, Calendar Adjusted, SA, Index	Macrobond	SA	1
France, Manufacturing, Optical Instruments & Photographic Equipment, Calendar Adjusted, SA, Index	Macrobond	SA	1
France, Manufacturing, Electric Lighting Equipment, Calendar Adjusted, SA, Index	Macrobond	SA	1
France, Manufacturing, Other Electrical Equipment, Calendar Adjusted, SA, Index	Macrobond	SA	1
France, Manufacturing, Repair of Fabricated Metal Products, Machinery & Equipment, Calendar Adjusted, SA, Index	Macrobond	SA	1
France, Manufacturing, Electrical Equipment, Calendar Adjusted, SA, Index	Macrobond	SA	1
Materials			
France, Manufacturing, Clay Building Materials, Calendar Adjusted, SA, Index	Macrobond	SA	1
Employment by skill and gender			
France, Metropolitan, Unemployment, Job Seekers, Men, Total, Categories A, B & C, Calendar Adjusted, SA	Macrobond	SA	1
France, Metropolitan, Unemployment, Job Seekers, Women & Men, Under 25 Years, Categories A, B & C, Calendar Adjusted, SA	Macrobond	SA	1
France, Metropolitan, Unemployment, Job Seekers, Women & Men, Aged 25-49 Years, Categories A, B & C, Calendar Adjusted, SA	Macrobond	SA	1
France, Metropolitan, Unemployment, Job Seekers, Women & Men, Aged 50 & More, Categories A, B & C, Calendar Adjusted, SA	Macrobond	SA	1
France, Unemployment, Job Seekers, Women & Men, Total, Categories A, B & C, Calendar Adjusted, SA	Macrobond	SA	1
France, Metropolitan, Unemployment, Job Seekers, Men, Under 25 Years, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Men, Aged 25-49 Years, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Men, Aged 50 & More, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Men, Total, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women, Under 25 Years, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women, Aged 25-49 Years, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women, Aged 50 & More, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women, Total, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women & Men, Under 25 Years, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women & Men, Aged 25-49 Years, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women & Men, Aged 50 & More, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women & Men, Total, Categories A, B & C	Macrobond		1
France, Unemployment, Job Seekers, Women & Men, Total, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Men, Labourers, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women, Labourers, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women & Men, Labourers, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Men, Professional Workers, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women, Professional Workers, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women & Men, Professional Workers, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Men, Skilled Manual Workers, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women, Skilled Manual Workers, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women & Men, Skilled Manual Workers, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Men, Non-Qualified Employed Persons, Categories A, B & C	Macrobond		1

France, Metropolitan, Unemployment, Job Seekers, Women, Non-Qualified Employed Persons, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Women & Men, Non-Qualified Employed Persons, Categories A, B & C	Macrobond		1
France, Metropolitan, Unemployment, Job Seekers, Men, Qualified Employed Persons, Categories A, B & C	Macrobond		1
Trade			
Credit			
France, Deposits & Loans, Credit Institutions, Loans, By Entity, to Households & NPISH, Loans for House Purchasing Adjusted for Sales & Securitisation, Total, Flows, EUR	Macrobond		1
France, Deposits & Loans, Credit Institutions, Loans, By Entity, to Households & NPISH, Loans for Other Purposes Adjusted for Sales & Securitisation, Total, Flows, EUR	Macrobond		1
France, Deposits & Loans, Credit Institutions, Loans, By Entity, to Households & NPISH, Loans Adjusted for Sales & Securitisation, Total, Flows, EUR	Macrobond		1
Durables			
France, OECD MEI, CLI New Car Registrations, SA	Macrobond	SA	1
France, OECD MEI, Total Car Registrations, SA	Macrobond	SA	1
France, OECD MEI, Passenger Car Registrations, SA, Index	Macrobond	SA	1
Retail			
France, OECD MEI, Total Retail Trade (Volume), SA, Index	Macrobond	SA	1
France, OECD MEI, Total Retail Trade (Value), SA, Index	Macrobond	SA	1
France, Domestic Trade, Vehicle Sales & Registrations, New, Passenger Cars, Total, Calendar Adjusted, SA	Macrobond	SA	0
France, Eurostat, Retail Trade & Services, Total Market, Retail Sale of Automotive Fuel in Specialised Stores, Calendar Adjusted, Index	Macrobond		2
France, Eurostat, Retail Trade & Services, Total Market, Retail Sale via Mail Order Houses or via Internet, Index	Macrobond		2
France, Eurostat, Retail Trade & Services, Total Market, Retail Sale of Food, Beverages & Tobacco, Trend Adjusted, Index	Macrobond		1
France, Eurostat, Retail Trade & Services, Total Market, Retail Sale of Textiles, Clothing, Footware & Leather Goods in Specialised Stores, Index	Macrobond		2
France, Eurostat, Retail Trade & Services, Total Market, Retail Sale of Textiles, Clothing, Footware & Leather Goods in Specialised Stores, Calendar Adjusted, Index	Macrobond		2
France, Eurostat, Retail Trade & Services, Total Market, Dispensing Chemist, Retail Sale of Medical & Orthopaedic Goods, Cosmetic & Toilet Articles in Specialised Stores, Calendar Adjusted, Index	Macrobond		2
France, Eurostat, Retail Trade & Services, Total Market, Retail Sale of Non-Food Products (Incl. Fuel), Index	Macrobond		1
France, Eurostat, Retail Trade & Services, Total Market, Retail Sale of Non-Food Products (Excl. Fuel), Index	Macrobond		1
Foreign trade			
France, Foreign Trade, Trade Balance, Calendar Adjusted, SA, EUR	Macrobond	SA	1
France, Foreign Trade, Export, Calendar Adjusted, SA, EUR	Macrobond	SA	1
France, Foreign Trade, Import, Calendar Adjusted, SA, EUR	Macrobond		1
France, OECD MEI, BOP Capital Account Credit, EUR	Macrobond		1
France, OECD MEI, BOP Capital Account Debit, EUR	Macrobond		1
Surveys			
Retail			
France, OECD MEI, Manufacturing Business Situation Future, SA	Macrobond	SA	0
France, OECD MEI, Manufacturing Finished Goods Stocks Level, SA	Macrobond	SA	0
France, OECD MEI, Manufacturing Production Future Tendency, SA	Macrobond	SA	0
France, OECD MEI, Manufacturing Production Tendency, SA	Macrobond	SA	0
France, OECD MEI, Manufacturing Selling Prices Future Tendency, SA	Macrobond	SA	0
France, OECD MEI, Manufacturing Industrial Confidence Indicator, SA	Macrobond	SA	0

France, OECD MEI, Manufacturing Export Order Books Level, SA	Macrobond	SA	0
Consumers			
France, Consumer Surveys, INSEE, Consumer Confidence Indicator, General Economic Situation, Past 12 Months, Balance of Replies, SA	Macrobond	SA	0
France, Consumer Surveys, INSEE, Consumer Confidence Indicator, General Economic Situation, Next 12 Months, Balance of Replies, SA	Macrobond	SA	0
France, Consumer Surveys, INSEE, Consumer Confidence Indicator, Major Purchases Intentions, Next 12 Months, Balance of Replies, SA	Macrobond	SA	0
France, Consumer Surveys, INSEE, Consumer Confidence Indicator, Financial Situation, Last 12 Months, Balance of Replies, SA	Macrobond	SA	0
France, Consumer Surveys, INSEE, Consumer Confidence Indicator, Financial Situation, Next 12 Months, Balance of Replies, SA	Macrobond	SA	0
Industry			
France, Business Surveys, INSEE, Building Industry, Global, Past Activity Tendency	Macrobond		0
France, Business Surveys, INSEE, Building Industry, Global, Expected Activity	Macrobond		0
France, Business Surveys, INSEE, Building Industry, Global, Order Books Level	Macrobond		0
France, Business Surveys, INSEE, Building Industry, Global, Past Workforce Size	Macrobond		0
France, Business Surveys, Bank of France, Industry, Inventories of Final Goods, Manufacturing Industry, SA	Macrobond	SA	0
France, Business Surveys, Bank of France, Industry, Current Order Books, Manufacturing Industry, SA	Macrobond	SA	0
France, Business Surveys, INSEE, Industry, Manufacturing, Personal Production Expectations, Balance of Replies, SA	Macrobond	SA	0
France, Business Surveys, INSEE, Industry, Manufacturing, Demand & Export Order Books, Balance of Replies, SA	Macrobond	SA	0
France, Business Surveys, INSEE, Industry, Manufacturing, General Production Expectations, Balance of Replies, SA	Macrobond	SA	0
France, Business Surveys, DG ECFIN, Retail Trade Confidence Indicator, Balance, SA	Macrobond	SA	0
France, Business Surveys, DG ECFIN, Construction Confidence Indicator, Balance, SA	Macrobond	SA	0
France, Business Surveys, Bank of France, Industry, Current Order Books, Manufacture of Food Products, Beverages & Tobacco Products, SA	Macrobond	SA	0
France, Business Surveys, Bank of France, Industry, Current Order Books, Manufacture of Electrical, Computer & Electronic Equipment, Manufacture of Machinery, SA	Macrobond	SA	0
France, Business Surveys, Bank of France, Industry, Current Order Books, Computer, Electronic & Optical Products, SA	Macrobond	SA	0
France, Business Surveys, Bank of France, Industry, Current Order Books, Machinery & Equipment, SA	Macrobond	SA	0
France, Business Surveys, Bank of France, Industry, Current Order Books, Transport Equipment, SA	Macrobond	SA	0
France, Business Surveys, Bank of France, Industry, Current Order Books, Automotive Industry, SA	Macrobond	SA	0
France, Business Surveys, Bank of France, Industry, Current Order Books, Other Transport Equipment, SA	Macrobond	SA	0
France, Business Surveys, Bank of France, Industry, Current Order Books, Other Manufacturing, SA	Macrobond	SA	0
France, Business Surveys, Bank of France, Industry, Current Order Books, Metal & Metal Products Manufacturing, SA	Macrobond	SA	0
France, Business Surveys, Bank of France, Industry, Current Order Books, Other Manufacturing Industries (Including Repair & Installation of Machinery), SA	Macrobond	SA	0
Services			
France, Service Surveys, DG ECFIN, Services Confidence Indicator, Balance, SA	Macrobond	SA	0
France, Service Surveys, INSEE, Services, Past Trend of Employment, All Non-Temporary Services, Including Transportation, Balance of Replies, SA	Macrobond	SA	0
France, Service Surveys, INSEE, Services, Expected Trend of Activity, All Non-Temporary Services, Including Transportation, Balance of Replies, SA	Macrobond	SA	0
France, Service Surveys, INSEE, Services, Past Trend of Activity, All Non-Temporary Services, Including Transportation, Balance of Replies, SA	Macrobond	SA	0

Retail trade			
France, Business Surveys, DG ECFIN, Retail Trade Confidence Indicator, Business Activity (Sales) Development over the Past 3 Months, Balance, SA	Macrobond	SA	0
France, Business Surveys, DG ECFIN, Retail Trade Confidence Indicator, Business Activity Expectations over the Next 3 Months, Balance, SA	Macrobond	SA	0
France, Business Surveys, DG ECFIN, Retail Trade Confidence Indicator, Employment Expectations over the Next 3 Months, Balance, SA	Macrobond	SA	0
France, OECD MEI, Retail Trade Orders Intentions, SA	Macrobond	SA	0
Prices			
France, Consumer Price Index, Total, Index	Macrobond		0
France, Consumer Price Index, Housing, Water, Electricity, Gas & Other Fuels, Rent of Primary Residence, Index	Macrobond		0
France, Eurostat, Producer Prices Index, Domestic Market, Manufacture of Plastics Products, Change P/P	Macrobond		1
Germany, Bundesbank, Price of Gold in London, Afternoon Fixing *, 1 Ounce of Fine Gold = USD ..., USD	Macrobond		0
World, IMF IFS, International Transactions, Export Prices, Linseed Oil (Any Origin)	Macrobond		6
Commodity Indices, UNCTAD, Price Index, End of Period, USD	Macrobond		0
Financial sector			
Indexes			
NYSE Euronext Paris, cac40 (^FCHI), price index, beginning of period, EUR	Macrobond		0
United Kingdom, Equity Indices, FTSE, All-Share, Index, Price Return, End of Period, GBP	Macrobond		0
Germany, Bundesbank, Capital Market Statistics, General Survey, Key Figures from the Capital Market Statistics 2, DAX Performance Index, End 1987 = 1000, End of Month, Index	Macrobond		0
Japan, Economic Sentiment Surveys, ZEW, Financial Market Report, Stock Market, Nikkei 225, Balance	Macrobond		0
United States, Equity Indices, S&P, 500, Index (Shiller), Cyclically Adjusted P/E Ratio (CAPE)	Macrobond		0
Exchange rates			
France, FX Indices, BIS, Real Effective Exchange Rate Index, CPI Based, Broad	Macrobond		
France, FX Indices, BIS, Nominal Effective Exchange Rate Index, Broad	Macrobond		0
REER Euro/Chinese yuan, CPI deflated	BCE		0
REER Euro/UK pound, CPI deflated	BCE		0
REER Euro/Japanese yen, CPI deflated	BCE		0
REER Euro/US dollar, CPI deflated	BCE		0
Interest rates			
Taux de référence des bons de trésor à 3 mois - moyenne mensuelle	BDF		0
Taux de référence des bons de trésor à 12 mois - moyenne mensuelle	BDF		0
France, Government Benchmarks, Eurostat, Government Bond, 10 Year, Yield	Macrobond		0
Loans			
France, Deposits & Loans, Credit Institutions, Loans, By Entity, to Domestic Non-Financial Corporations, Loans Adjusted for Sales & Securitisation, Total, EUR	Macrobond		1
France, Deposits & Loans, Credit Institutions, Loans, By Entity, to Domestic Non-Financial Corporations, Investment Loans Adjusted for Sales & Securitisation, Total, EUR	Macrobond		1
France, Deposits & Loans, Credit Institutions, Loans, By Entity, to Domestic Non-Financial Corporations, Short-Term Loans Adjusted for Sales & Securitisation, Total, EUR	Macrobond		1
France, Deposits & Loans, Credit Institutions, Loans, By Entity, to Domestic Non-Financial Corporations, Other Loans Adjusted for Sales & Securitisation, Total, EUR	Macrobond		1
Monetary aggregates			
France, Monetary Aggregates, M1, Total, EUR	Macrobond		1

France, Monetary Aggregates, M2, Total, EUR	Macrobond		2
France, Monetary Aggregates, M3, Total, EUR	Macrobond		2
International			
Germany, Economic Sentiment Surveys, ZEW, Financial Market Report, Current Economic Situation, Balance	Macrobond		0
Germany, OECD MEI, Manufacturing Business Situation Present, SA	Macrobond	SA	1
Germany, OECD MEI, Production Of Total Industry, SA, Index	Macrobond	SA	3
United States, Employment, CPS, 16 Years & Over, SA	Macrobond	SA	1
United States, Unemployment, CPS, 16 Years & Over, Rate, SA	Macrobond	SA	1
United States, Industrial Production, Total, SA, Index	Macrobond	SA	1
United States, Domestic Trade, Retail Trade, Retail Sales, Total, Calendar Adjusted, SA, USD	Macrobond	SA	1
United States, Industrial Production, Industry Group, Manufacturing, Total (SIC), SA, Index	Macrobond	SA	1
United States, Equity Indices, S&P, 500, Index, Price Return, End of Period, USD	Macrobond		1

Table A.2. List of series used for the one-step estimation

N	Series name	Lag
1	France, Capacity Utilization, Total Industry, SA	1
2	France, Consumer Surveys, INSEE, Consumer Confidence Indicator, Synthetic Index, SA	0
3	France, Domestic Trade, Vehicle Sales & Registrations, New, Passenger Cars, Total, Calendar Adjusted, SA	0
4	France, OECD MEI, Retail Trade Orders Intentions, SA	0
5	France, OECD MEI, CPI All Items, Change Y/Y	3
6	France, OECD MEI, Production Of Total Industry, SA, Index	3
7	France, OECD MEI, Total Retail Trade (Volume), SA, Change P/P	1
8	France, Metropolitan, Unemployment, Job Seekers, Men, Total, Categories A, B & C, Calendar Adjusted, SA	1
9	France, OECD MEI, Manufacturing Finished Goods Stocks Level, SA	0
10	France, Economic Sentiment Surveys, ZEW, Financial Market Report, Stock Market, CAC-40, Balance	1
11	France, Foreign Trade, Trade Balance, Calendar Adjusted, SA, EUR	1
12	France, Foreign Trade, Export, Calendar Adjusted, SA, EUR	2
13	France, Foreign Trade, Import, Calendar Adjusted, SA, EUR	2
14	Taux de référence des bons de trésor à 3 mois - moyenne mensuelle	3
15	Taux de référence des bons de trésor à 12 mois - moyenne mensuelle	3
16	United Kingdom, Equity Indices, FTSE, All-Share, Index, Price Return, End of Period, GBP	0
17	Japan, Economic Sentiment Surveys, ZEW, Financial Market Report, Stock Market, Nikkei 225, Balance	0
18	United States, Equity Indices, S&P, 500, Index (Shiller), Cyclically Adjusted P/E Ratio (CAPE)	0
19	France, OECD MEI, Manufacturing Business Situation Future, SA	0
20	France, OECD MEI, Manufacturing Industrial Confidence Indicator, SA	3
21	France, Business Surveys, INSEE, Building Industry, Global, Expected Activity	0
22	France, Business Surveys, INSEE, Building Industry, Global, Order Books Level	0
23	France, Business Surveys, DG ECFIN, Retail Trade Confidence Indicator, Balance, SA	0
24	France, Business Surveys, DG ECFIN, Construction Confidence Indicator, Balance, SA	0
25	France, Service Surveys, DG ECFIN, Services Confidence Indicator, Balance, SA	0

Appendix B. One-step estimation results

Table B.1: Frequency of 25 French economic indicators in successful combinations for 1-step estimation

No	Freq.	Name of series	Lag
24	22	France, Business Surveys, DG ECFIN, Construction Confidence Indicator, Balance, SA (Business survey)	0
1	21	France, Capacity Utilization, Total Industry, SA	1
12	20	France, Foreign Trade, Export, Calendar Adjusted, SA, EUR	2
8	19	France, Metropolitan, Unemployment, Job Seekers, Men, Total, Categories A, B & C, Calendar Adjusted, SA	1
23	19	France, Business Surveys, DG ECFIN, Retail Trade Confidence Indicator, Balance, SA (Business survey)	0
11	18	France, Foreign Trade, Trade Balance, Calendar Adjusted, SA, EUR	1
4	16	France, OECD MEI, Retail Trade Orders Intentions, SA (Business survey)	0
7	15	France, OECD MEI, Total Retail Trade (Volume), SA, Change P/P	1
9	15	France, OECD MEI, Manufacturing Finished Goods Stocks Level, SA	0
17	13	Japan, Economic Sentiment Surveys, ZEW, Financial Market Report, Stock Market, Nikkei 225, Balance	0
18	12	United States, Equity Indices, S&P, 500, Index (Shiller), Cyclically Adjusted P/E Ratio (CAPE)	0
13	11	France, Foreign Trade, Import, Calendar Adjusted, SA, EUR	2
6	10	France, OECD MEI, Production Of Total Industry, SA, Index	3
14	10	Taux de référence des bons de trésor à 3 mois - moyenne mensuelle	3
16	10	United Kingdom, Equity Indices, FTSE, All-Share, Index, Price Return, End of Period, GBP	0
22	10	France, Business Surveys, INSEE, Building Industry, Global, Order Books Level	0
3	8	France, Domestic Trade, Vehicle Sales & Registrations, New, Passenger Cars, Total, Calendar Adjusted, SA	0
25	8	France, Service Surveys, DG ECFIN, Services Confidence Indicator, Balance, SA	0
2	7	France, Consumer Surveys, INSEE, Consumer Confidence Indicator, Synthetic Index, SA	0
15	7	Taux de référence des bons de trésor à 12 mois - moyenne mensuelle	3
19	6	France, OECD MEI, Manufacturing Business Situation Future, SA	0
20	5	France, OECD MEI, Manufacturing Industrial Confidence Indicator, SA	3
21	4	France, Business Surveys, INSEE, Building Industry, Global, Expected Activity	0
5	2	France, OECD MEI, CPI All Items, Change Y/Y	3
10	0	France, Economic Sentiment Surveys, ZEW, Financial Market Report, Stock Market, CAC-40, Balance	1

The numbers in the last column stand for the length of lag of data updates publication, in months

Table B.2: Crises and their most descriptive sets of economic indicators

Crisis	N of combination	Composition				FPS/T	QPS
March 1992-October 1993	8816	7	8	11	22	0,0000	0,0142
	10521	9	12	18	23	0,0000	0,0331
	10635	9	14	17	23	0,0000	0,0580
April 1995-January 1997	3913	3	4	11	24	0,1828	0,1141
	10635	6	8	12	25	0,1828	0,1171
	8816	7	8	11	22	0,1828	0,1216
January 2001-June 2003	3913	3	9	12	25	0,0000	0,0108
	3394	2	11	16	24	0,0000	0,0460
	5820	4	7	17	24	0,0000	0,0477
January 2008-June 2009	3913	3	9	12	25	0,0000	0,0108
	3394	2	11	16	24	0,0000	0,0460
	5820	4	7	17	24	0,0000	0,0477
October 2011-January 2013	8816	7	8	11	22	0,0000	0,0205
	3913	3	9	12	25	0,0625	0,0828
	8817	7	8	11	23	0,0625	0,0870

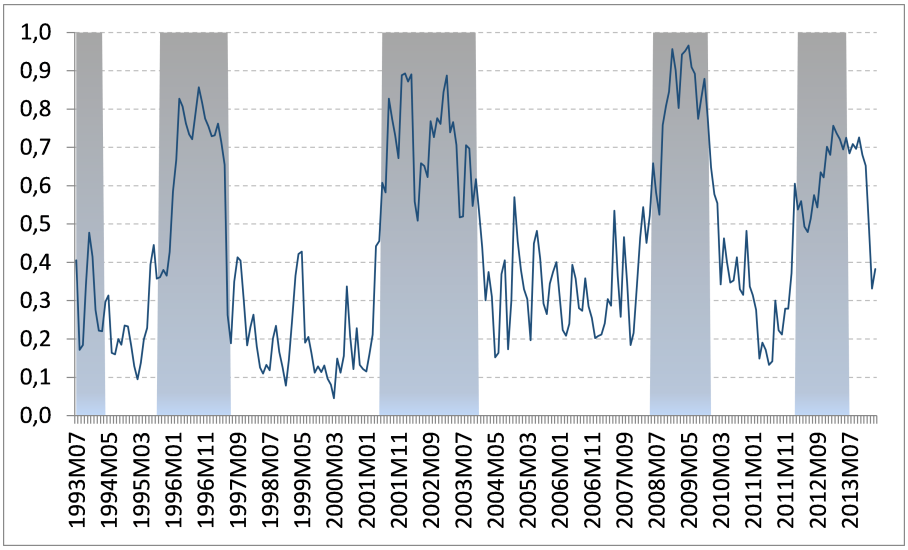
Table B.3: Top 25 combinations with the lowest QPS and FPS indicators. The first 8 entries belong to the lowest 10% by both indicators simultaneously

Combination	FPS	QPS	Component series				Factor loadings			
5820	35	0,1287	**4**	7	17	**24**	**0,3665**	0,1006	-0,0026	**0,4463**
3394	39	0,1315	2	11	**16**	**24**	0,1775	-0,0584	**0,6137**	**0,3779**
3913	45	0,1254	3	4	11	**24**	0,0001	0,1807	-0,0461	**0,8876**
6089	46	0,1328	4	9	**19**	24	0,3058	-0,0799	**0,6722**	0,3337
5757	46	0,1412	**4**	7	11	**24**	**0,3139**	0,0933	-0,0768	**0,3958**
10233	47	0,1184	8	18	23	**24**	0,0738	-0,0452	-0,0805	**-0,3292**
9982	49	0,1493	**8**	12	23	24	**-0,1454**	0,0247	0,1301	0,0005
8817	50	0,1492	7	**8**	11	23	0,0216	**-0,1829**	-0,0371	-0,0013
9663	54	0,1674	8	9	15	23	-0,1125	-0,0945	0,0344	0,1510
1305	58	0,1963	1	8	16	22	0,4595	0,0025	0,7876	0,0015
1391	58	0,2135	1	9	13	18	0,0983	-0,1404	0,0905	-0,0010
6026	59	0,1656	4	9	12	24	0,2292	-0,0746	0,1633	0,6130
618	62	0,2091	1	4	13	15	0,2255	0,1715	0,2888	-0,0014
5892	64	0,1724	4	8	11	23	0,0880	-0,2649	-0,0377	-0,0031
5969	64	0,1795	4	8	19	24	0,3272	-0,0022	0,5487	0,3608
12327	64	0,2092	15	16	17	24	-0,0010	1,0500	-0,0027	0,3222
10521	65	0,1993	9	12	18	23	-0,2665	0,0362	0,0384	0,1614
12612	67	0,2147	18	22	23	24	0,0219	0,0130	0,0738	0,0002
9425	68	0,2233	7	14	24	25	0,0016	-0,0004	0,5101	0,0428
8818	69	0,1702	7	8	11	24	-0,1141	-0,0003	-0,0066	-0,8400
12178	70	0,1799	14	15	18	24	0,0636	0,0063	0,0082	0,7306
11556	71	0,1862	11	16	21	22	-0,0006	0,9812	0,0170	-0,0007
1664	71	0,1863	1	12	13	17	0,8973	0,2825	0,3013	0,0495
8070	71	0,2058	6	8	18	22	0,0262	-0,2072	0,0283	0,0328
11758	72	0,1912	12	14	20	23	0,1444	0,0687	0,6750	0,1026

Figure B.1. Results of one-step estimation: filtered probability to be in a crisis in a current period (blue line) vs OECD recession dating (shaded area, 1 corresponds to recession)

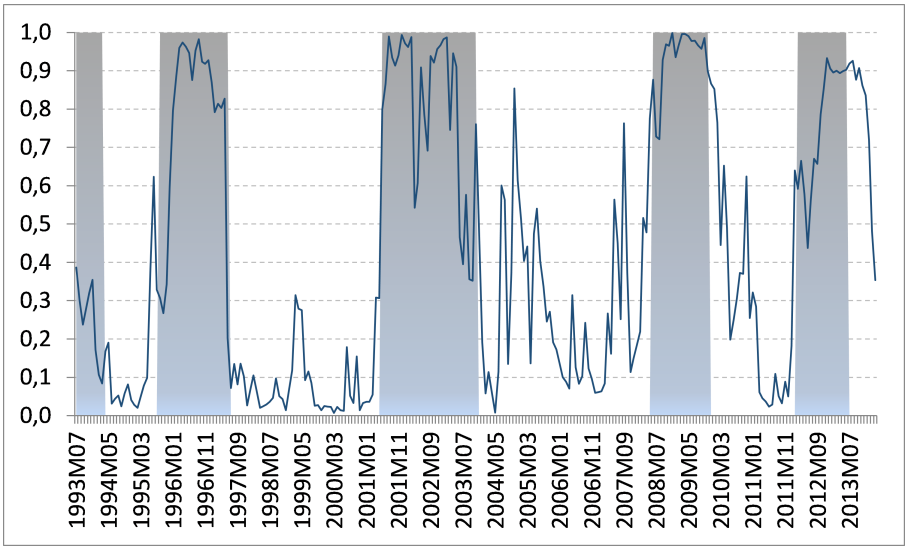
Combination 5820:

4 - France, OECD MEI, Retail Trade Orders Intentions, SA
7 - France, OECD MEI, Total Retail Trade (Volume), SA, Change P/P
17 - Japan, Economic Sentiment Surveys, ZEW, Financial Market Report, Stock Market, Nikkei 225, Balance
24 - France, Business Surveys, DG ECFIN, Construction Confidence Indicator, Balance, SA



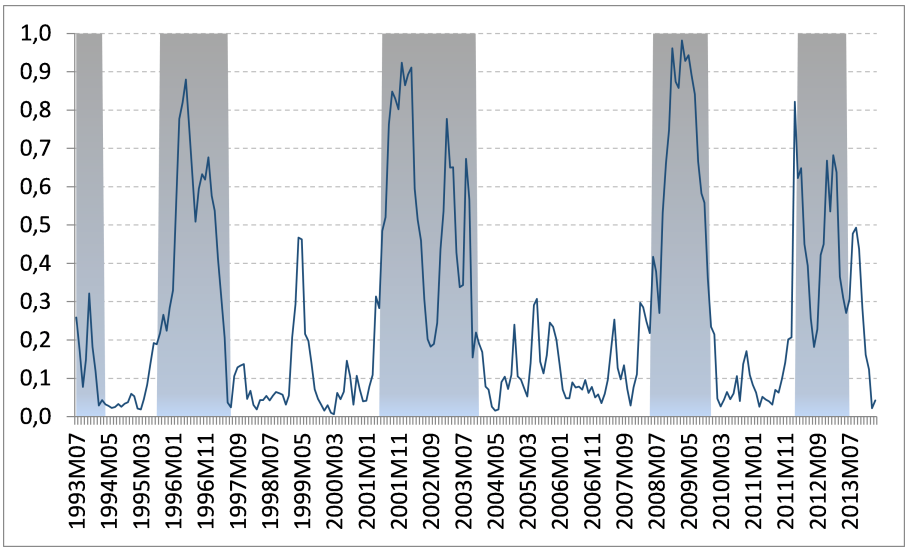
Combination 3913

3 - France, Domestic Trade, Vehicle Sales & Registrations, New, Passenger Cars, Total, Calendar Adjusted, SA
4 - France, OECD MEI, Retail Trade Orders Intentions, SA
11 - France, Foreign Trade, Trade Balance, Calendar Adjusted, SA, EUR
24 - France, Business Surveys, DG ECFIN, Construction Confidence Indicator, Balance, SA



Combination 6089

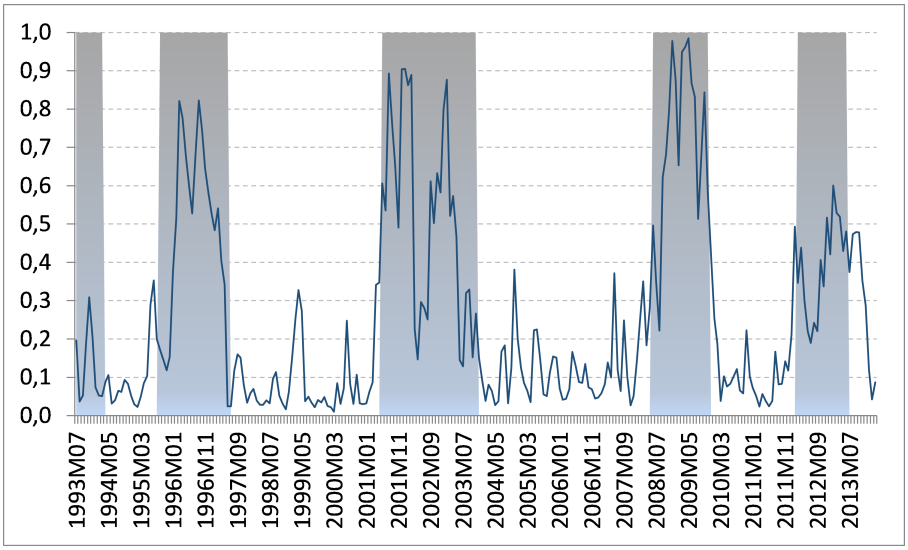
4 - France, OECD MEI, Retail Trade Orders Intentions, SA
9 - France, OECD MEI, Manufacturing Finished Goods Stocks Level, SA
19 - France, OECD MEI, Manufacturing Business Situation Future, SA
24 - France, Business Surveys, DG ECFIN, Construction Confidence Indicator, Balance, SA



Combination 5757

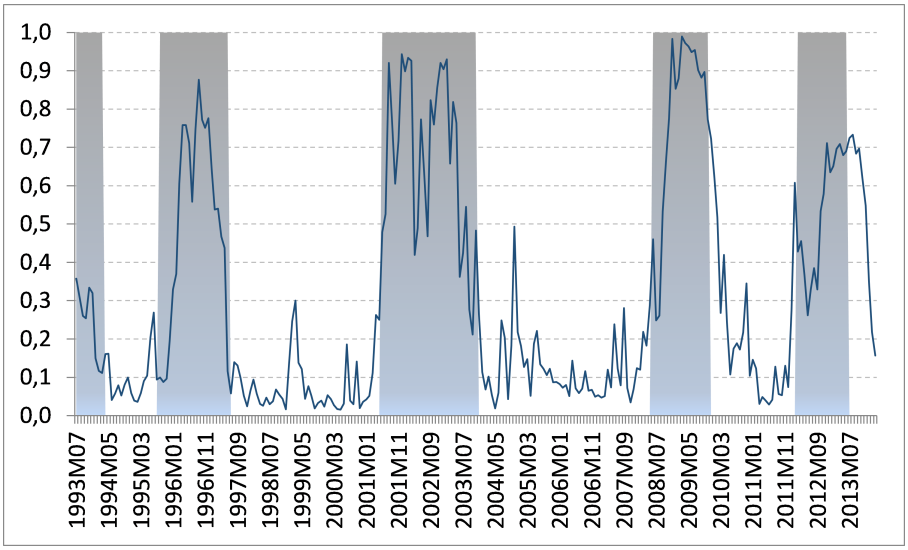
4 - France, OECD MEI, Retail Trade Orders Intentions, SA
7 - France, OECD MEI, Total Retail Trade (Volume), SA, Change P/P
11 - France, Foreign Trade, Trade Balance, Calendar Adjusted, SA, EUR

24 - France, Business Surveys, DG ECFIN, Construction Confidence Indicator, Balance, SA



Combination 10233

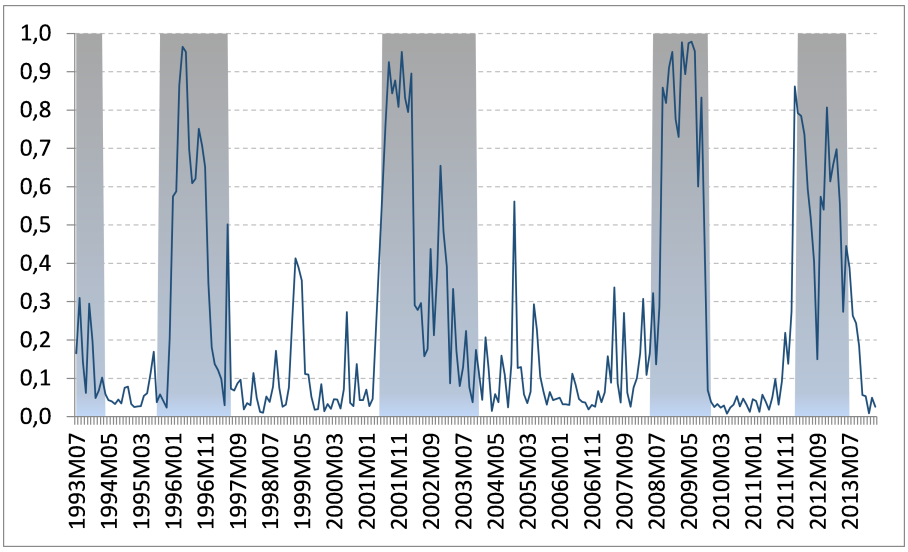
8 - Unemployed, total
18 - United States, Equity Indices, S&P, 500, Index (Shiller), Cyclically Adjusted P/E Ratio (CAPE)
23 - France, Business Surveys, DG ECFIN, Retail Trade Confidence Indicator, Balance, SA
24 - France, Business Surveys, DG ECFIN, Construction Confidence Indicator, Balance, SA



Combination 9982

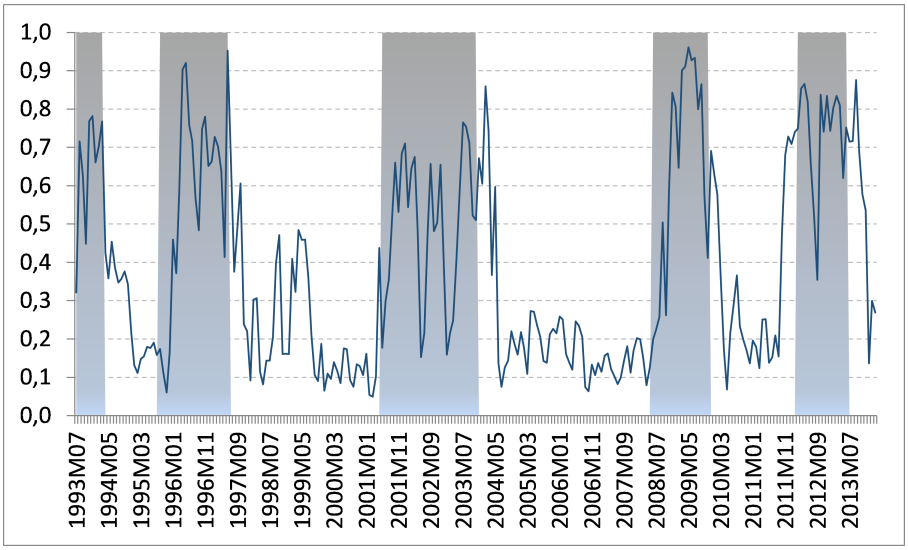
8 - Unemployed, total

12 - France, Foreign Trade, Export, Calendar Adjusted, SA, EUR
23 - France, Business Surveys, DG ECFIN, Retail Trade Confidence Indicator, Balance, SA
24 - France, Business Surveys, DG ECFIN, Construction Confidence Indicator, Balance, SA



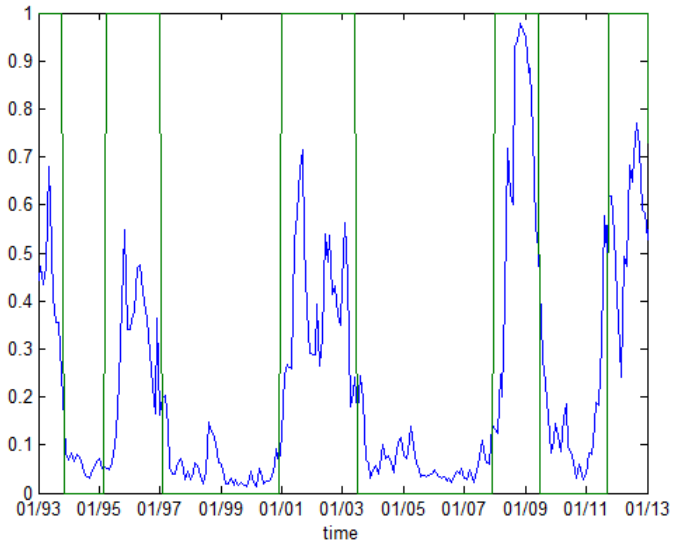
Combination 8817

7 - France, OECD MEI, Total Retail Trade (Volume), SA, Change P/P
8 - Unemployed, total
11 - France, Foreign Trade, Trade Balance, Calendar Adjusted, SA, EUR
23 - France, Business Surveys, DG ECFIN, Retail Trade Confidence Indicator, Balance, SA



Finally selected information set

Figure B.2. The filtered probability of recession, estimated with one-step method on 13 series of the finally selected information set (blue line) vs OECD recession dating (shaded area, 1 corresponds to recession)



The blue line corresponds to the filtered probability of recession,

Series:
4 - France, OECD MEI (Enquete de Conjoncture INSEE), Retail Trade Orders Intentions, SA;
8 - Unemployed, total
19 - France, OECD MEI (Enquete de Conjoncture INSEE), Manufacturing Business Situation Future, SA
24 - France, Business Surveys, DG ECFIN, Construction Confidence Indicator, Balance, SA
2 - France, Consumer Surveys, INSEE, Consumer Confidence Indicator, Synthetic Index, SA
3 - France, Domestic Trade, Vehicle Sales & Registrations, New, Passenger Cars, Total, Calendar Adjusted, SA
7 - France, OECD MEI, Total Retail Trade (Volume), SA, Change P/P
9 - France, OECD MEI, Manufacturing Finished Goods Stocks Level, SA
11 - France, Foreign Trade, Trade Balance, Calendar Adjusted, SA, EUR
12 - France, Foreign Trade, Export, Calendar Adjusted, SA, EUR
17 - Japan, Economic Sentiment Surveys, ZEW, Financial Market Report, Stock Market, Nikkei 225, Balance
18 - United States, Equity Indices, S&P, 500, Index (Shiller), Cyclically Adjusted P/E Ratio (CAPE)
23 - France, Business Surveys, DG ECFIN, Retail Trade Confidence Indicator, Balance, SA

Appendix C. Estimation results for one-step and two-step methods

Table C.1: Estimated parameters, one step and two step methods

	2step		1step							
Parameters	(switch in μ)	(switch in μ and σ^2)	5820	3394	3913	6089	5757	10233	9982	8817
ϕ_1	0,0010	0,0012	0,0018*	-0,0013	-0,0142*	-0,0031*	-0,0033*	0,8348*	0,1864*	0,0753*
ϕ_2	0,8926*	0,8685*	0,0016	0,0165*	-0,0070	0,0021*	0,0049	-0,2047*	0,7788*	0,6955*
ψ_{11}		-	-0,4524*	-0,0045	-0,4922*	-0,3708*	-0,3659*	0,0027	0,0626*	-0,7269*
ψ_{12}		-	0,0046*	0,1737*	-0,2011*	-0,0063*	-0,0012	-0,0027*	0,1096*	-0,4214*
ψ_{21}		-	-0,7354*	-0,6074*	-0,3727*	0,9060*	-0,7475*	0,9889*	-0,5624*	0,2608*
ψ_{22}		-	-0,4208*	-0,2116*	0,0016	0,0119	-0,4271*	-0,0003*	-0,2637*	0,3266*
ψ_{31}		-	0,8955*	-0,0041	-0,6637*	0,1708*	-0,6240*	0,5139*	0,4689*	-0,6276*
ψ_{32}		-	-0,0046	-0,0143*	-0,2873*	0,1148*	-0,2025*	0,3528*	0,2521*	-0,2046*
ψ_{41}		-	-0,0023	0,0700	-0,0043*	-0,0014*	-0,0056	0,0007*	0,0040*	0,0007*
ψ_{42}		-	-0,0025*	-0,0971*	-0,0075*	-0,0022*	-0,1115*	-0,0003	-0,0043*	-0,0031*
σ_1		-	0,6622	0,6114	0,6343	0,6470	0,6589	0,6228	0,7256	0,6714
σ_2		-	0,6736	0,6501	0,6331	0,8150	0,6823	0,9353	0,6539	0,7130
σ_3		-	0,7925	0,7028	0,6590	0,7136	0,6589	0,7410	0,7500	0,6609
σ_4		-	0,7244	0,6511	1,0006	0,6676	0,7260	0,6853	0,6905	0,7864
γ_1		-	0,3665*	0,1775*	0,0001*	0,3058*	0,3139*	0,0738*	-0,1454*	0,0216*
γ_2		-	0,1006*	-0,0584*	0,1807*	-0,0799*	0,0933*	-0,0452*	0,0247*	-0,1829*
γ_3		-	-0,0026*	0,6137*	-0,0461*	0,6722*	-0,0768*	-0,0805*	0,1301*	-0,0371*
γ_4		-	0,4463*	0,3779*	0,8876*	0,3337*	0,3958*	-0,3292*	0,0005*R	-0,0013*
μ_0	1,0452*	1,2251*	0,3089*	0,4263*	0,4710*	0,2107*	0,3075*	0,8431*	0,6056*	0,7906*
μ_1	-1,7789*	-1,5245*	-0,3162*	-0,3305*	-0,5072*	-0,7062*	-0,8129*	-0,2725*	-1,6863*	-1,1919*
$\sigma_{\eta 0}$	0,5770*	0,4028*	-	-	-	-	-	-	-	-
$\sigma_{\eta 1}$	0,5770*	0,7524*	-	-	-	-	-	-	-	-
p_{00}	0,9532*	0,9432*	0,9549	0,9346	0,9585	0,9728	0,9673	0,9636	0,9650	0,9352
p_{11}	0,9029*	0,9149*	0,9442	0,9103	0,9525	0,9284	0,9120	0,9385	0,8949	0,9011

Estimates marked with * are significant on 5% level of confidence probability. $\sigma_{\eta 0}$ and $\sigma_{\eta 1}$ stand for the standard error of η_t (the stochastic term in factor dynamics) in expansion and recession states, respectively.